NAPPFAST

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NCSU/CPHST/PERAL

NAPPFAST

North Carolina State University

APHIS

Plant

Pest

ForecAST

System

History of NAPPFAST

- Created in response to recommendations from Safeguarding American Plant Resources Review of PPQ
- Designed to predict potential establishment of invasive pest species: used for risk analysis and to aid CAPS survey and detection efforts
- Developed through an APHIS and NCSU cooperative agreement- **Funded by CAPS Program**

NAPPFAST

- Uses generic degree day, infection and disease models to examine the probability of occurrence of plant pest species
- Models linked through internet graphical user interface to 30 year national climate database (ZedX Inc.)
- Worldwide climate database to be established in 2004

Degree Day Background Primer

- "Phenology and development of most organisms follow a temperature dependent time scale" (Allen 1976)
- Attempts to integrate temperature and time started 250 + years ago
- Development is widely believed to follow a sigmoid shape

Degree Day Background Primer

- Organisms have base developmental temperature- minimum temperature below which no development occurs
- Organisms have set number of units to complete development - physiological time: measured in developmental units (DU) or degree days (DD)
- Parameters established from lab or field studies

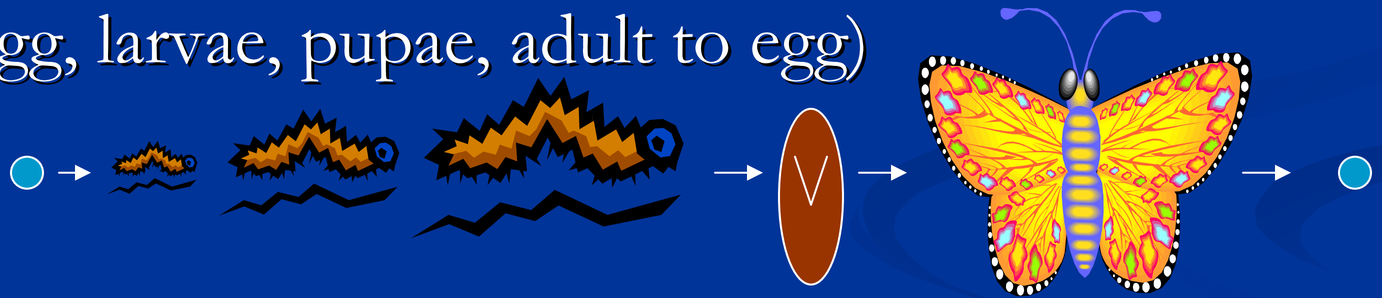
Degree Day Background Primer

- Example: *Ieata lotastuf*

  base temperature 10 C

  requires 365 DD to complete development

  (egg, larvae, pupae, adult to egg)



Degree days are typically calculated from average of high and low temperature for a 24 hour period above the base temperature

Degree Day Background Primer

Ieata lotastuf base temperature 10 C

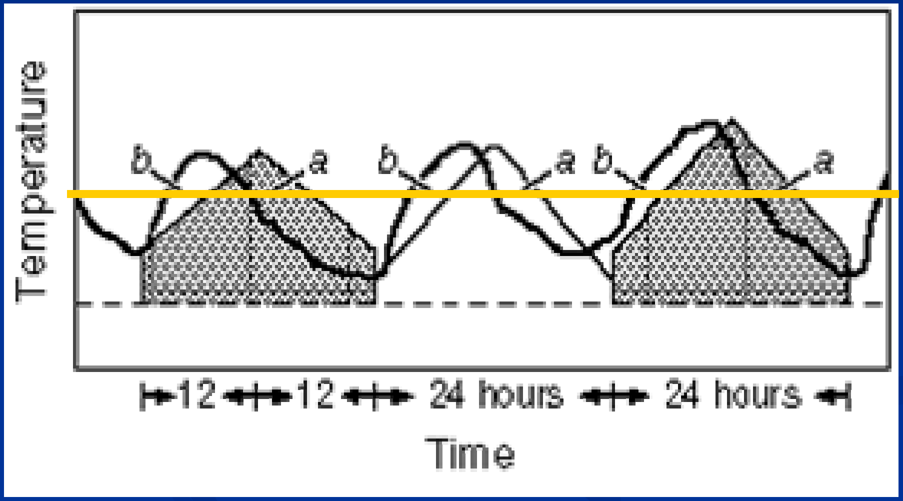
365 DD for development

If average daily temp was 11C: 1 DD (11-10) is accumulated and it would take 365 days at that temperature to complete development

If average daily temp was 20C: 10 DD (20-10) are accumulated and it would take 36.5 days at that temperature to complete development

Degree Day Background Primer

- Estimation of accumulated DD is simple in controlled environment, but becomes more complicated in nature as temperature fluctuations occur



Graph from UC Davis IPM website

What does this mean to me?

- Through the use of degree day models we can predict the occurrence of pests or their phenology
- More effective/efficient timing of scouting/trapping for particular stage of interest

Helicoverpa armigera
Old world bollworm

- Highly polyphagous pest- corn, cotton, citrus, tomatoes and tobacco
- Intercepted numerous times in inspections 280 ± 12 per year, 4,431 since 1985 (52 % JFK airport)

Pictures from CAB , 2003

HIS - Microsoft Internet Explorer

Lo

APHIS

Setup | History | Observation | Forecast

lected Stations

emove

Model Name

--

Action

Edit

Go

Draw

Country -- All --

St/Prov -- All --

Station -- All --

Save

Internet

Model Setup - Microsoft Internet Explorer

Model Name H. Amigera **Template** Insect Degree Day **Pest** Armyworm

Input/Output Matrix

	Variable	Unit	Base	Min	Max
Input 1	Degree Days	C	13.87		36
Output 1	Insect Stage				

+ Level - Level

	1st Instar >=	1st Instar <	2nd Instar >=	2nd Instar <	3rd Instar >=	3rd Instar <	4th Instar >=	4th Instar <	5th Instar >=	5th Instar <	Pupae >=	Pupae <	Adult >=	Adult <	Ovipositio >=	Ovipositio <
Overwinter											0	115	116	144	145	1
Gen. 1	176	375							376	402	403	550	551	579	580	6
Gen. 2	611	810							811	837	838	985	986	1014	1015	1
Gen. 3	1046	1245							1246	1272	1273	1420	1421	1449	1450	1
Gen. 4	1481	1680							1681	1707	1708	1855	1856	1884	1885	1
Gen. 5	1916	2115							2116	2142	2143	2290	2291	2319	2320	2
Gen. 6	2351	2550							2551	2577	2578	2725	2726	2754	2755	2
Gen. 7	2786	2985							2986	3012	3013	3160	3161	3189	3190	3
Gen. 8	3221	3420							3421	3447	3448	3595	3596	3624	3625	3

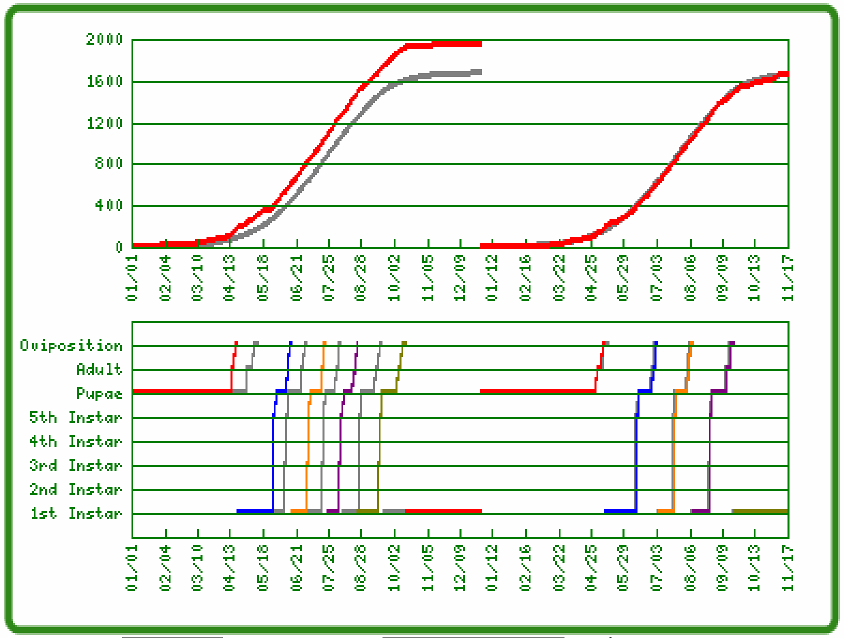
Save Print Reset

APHIS - Microsoft Internet Explorer

Logout

APHIS

Setup | History | Observation | Forecast



Format Graph **Output** Geo-Tif Go

Session Name --

Action Add Go

Model Name H. Amigera

Input Variable Degree Days

Output Variable Insect Stage

Interval Daily

Climatology 30 Years

Location

Country USA

St/Prov NC

Station KRDU - Raleigh / Durham, Ral

Or

Drawn Area --

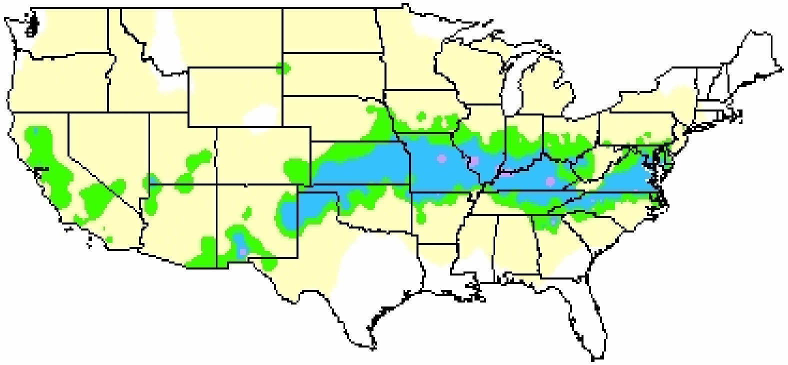
	Year	Month	Day
Begin Date	2002	Jan	1
End Date	2003	Nov	17

Apply Save Clear

Logout

Setup | History | Observation | Forecast

Insect Stage (05-14 - 05-21)



Search: Value = 'Overwinter - Adult'

Legend

H. Armigera Maps

<< Back

+ History

- Probability

  - Insect Stage

04-01 - 04-07	Load	Delete
04-01 - 04-07	Load	Delete
04-01 - 04-07	Load	Delete
04-01 - 04-07	Load	Delete
04-14 - 04-21	Load	Delete
05-01 - 05-07	Load	Delete
05-14 - 05-21	Load	Delete
06-01 - 06-07	Load	Delete
06-01 - 06-07	Load	Delete
06-01 - 06-07	Load	Delete

Format Map **Output** Geo-Tif Go

Legend - Microsoft Internet Explorer

Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

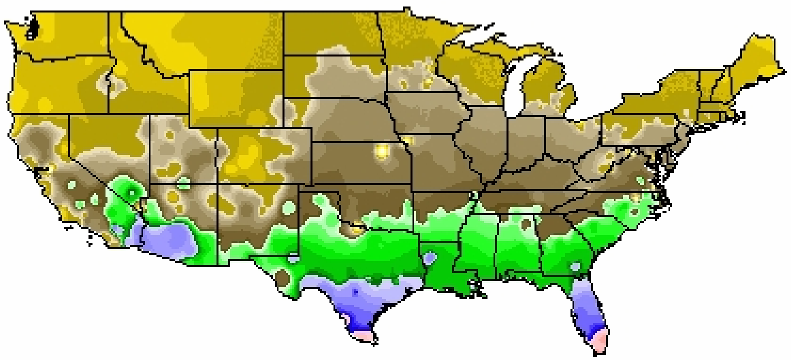
APHIS - Microsoft Internet Explorer

Logout

APHIS

Setup History Observation Forecast

Insect Stage (2002-07-04)



Legend

Format Map **Output** Geo-Tif Go

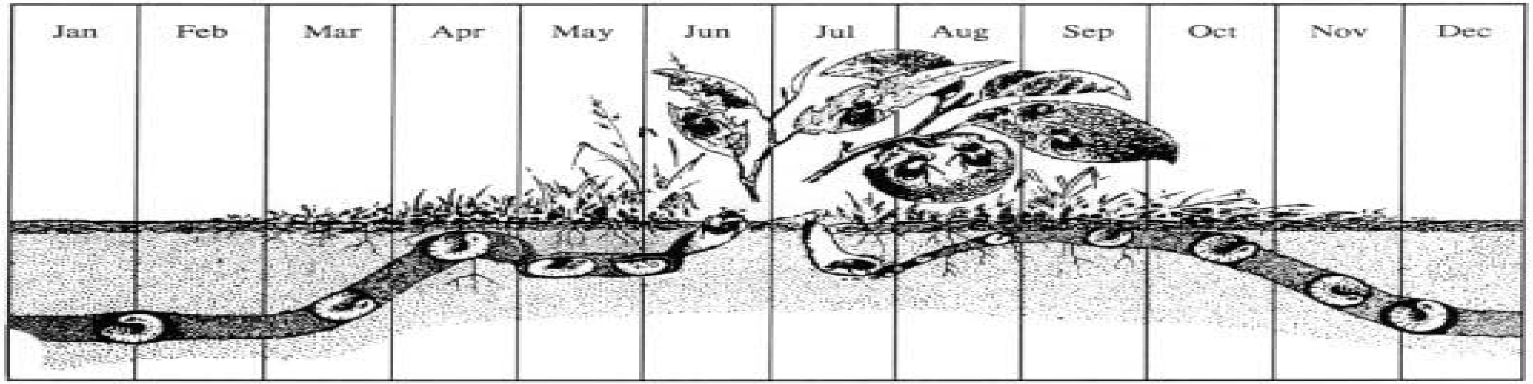
Legend - Microsoft Internet Explorer

Insect Stage

Overwinter	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 1	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 2	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 3	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 4	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 5	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 6	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 7	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.
Gen. 8	1st	2nd	3rd	4th	5th	Pupae	Adult	Ovi.

P. japonica general information

- Univoltine- one generation per year
- Overwinters typically as a third instar larvae

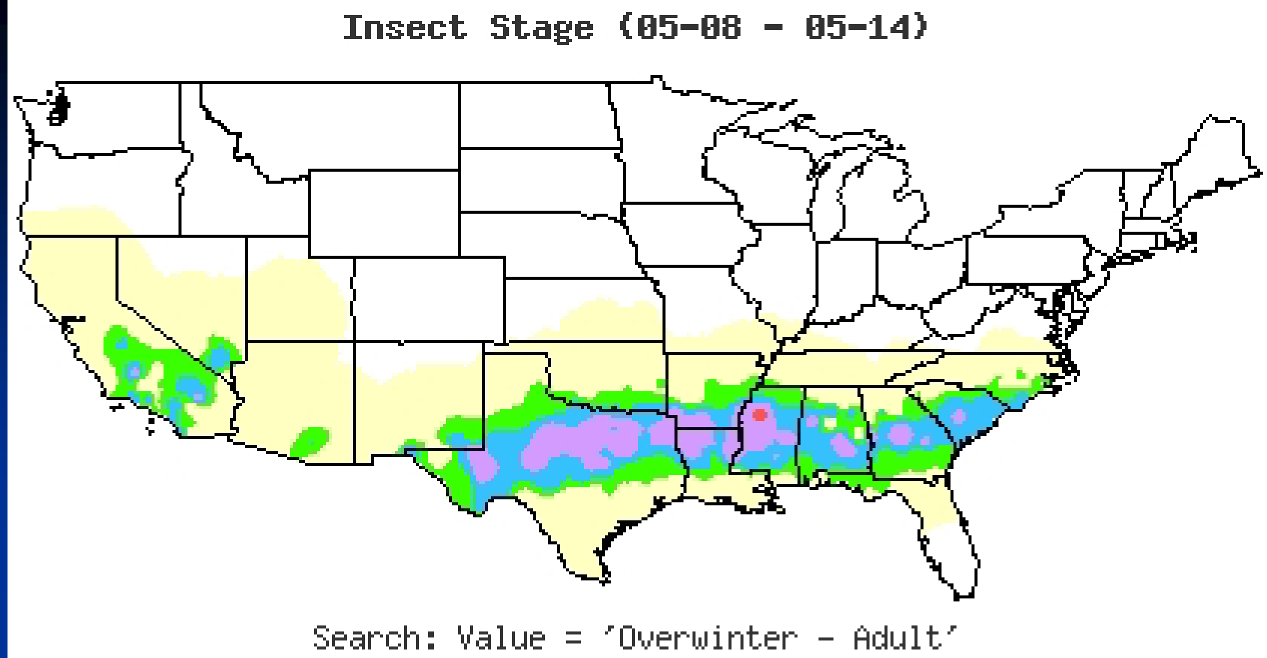


UGA1150134

Model Parameters

Japanese Beetle

	Stage	DD in stage	First entry	second entry
Overwintering stage	3rd instar	400	0	400
	Pupae	124	401	525
Low 10 C	Adult	117	526	643
Upper 34 C	egg	140	644	784
	first instar	222	785	1007
	Second instar	419	1008	1427
	third instar	720	1428	



Frequency of Occurrence (30year)

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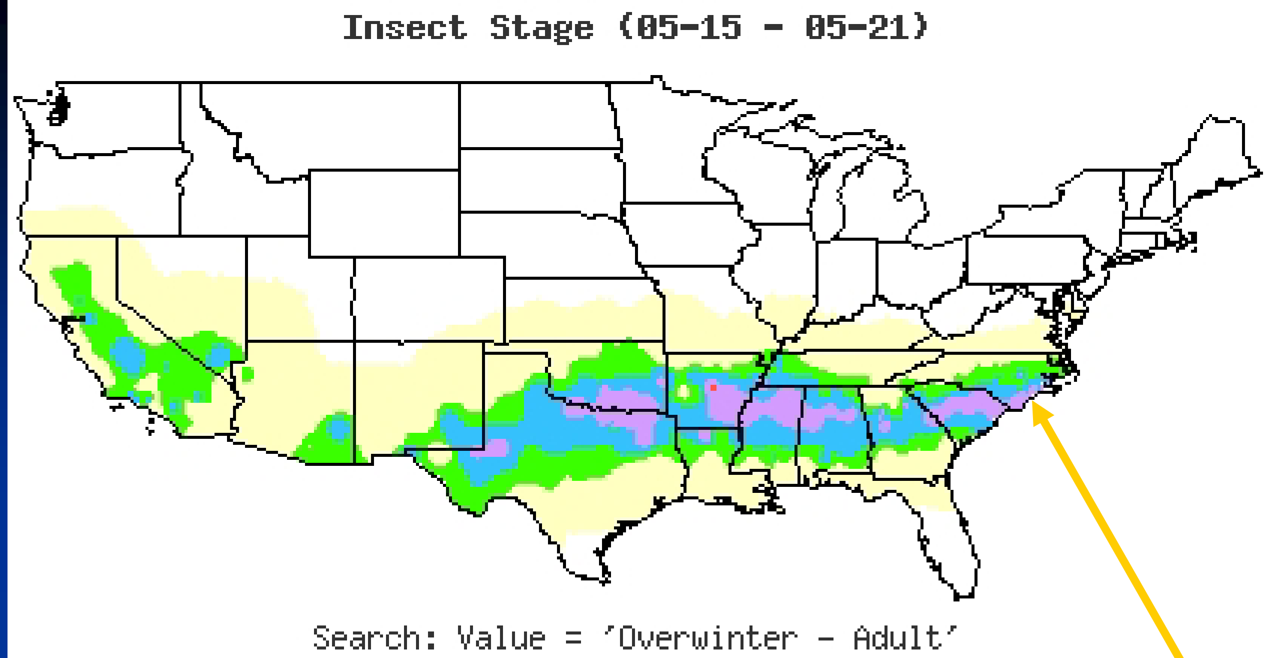
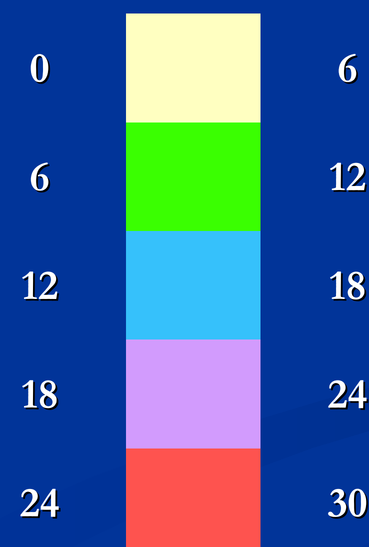
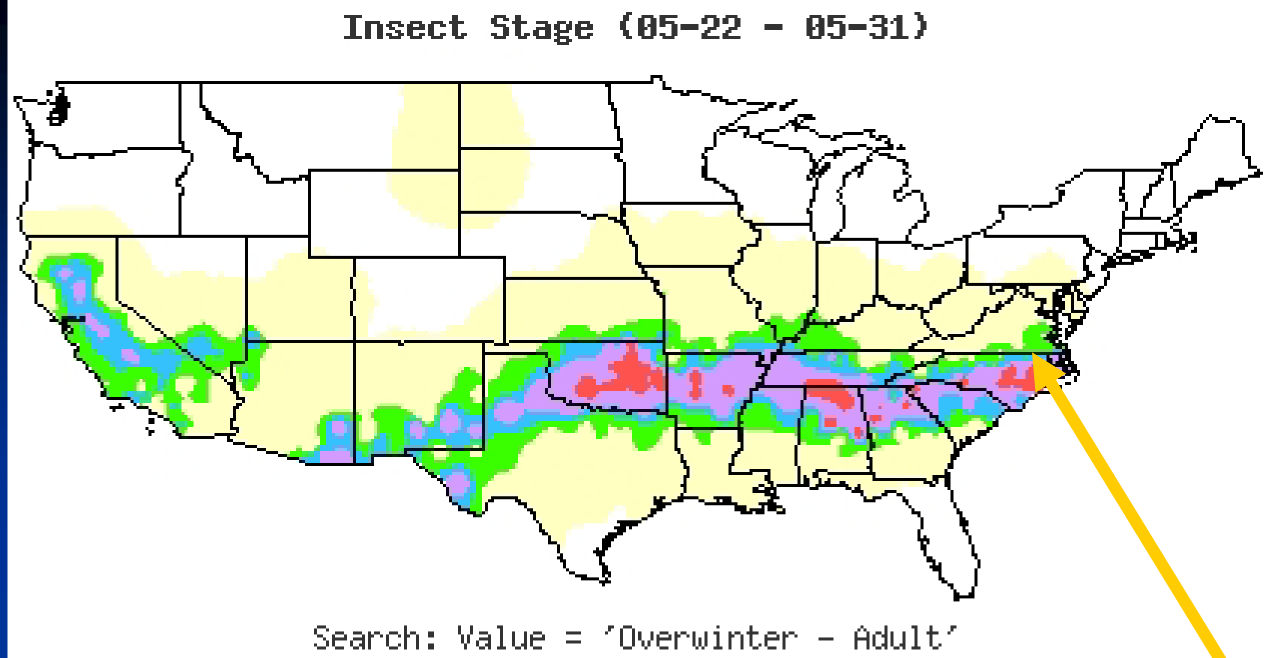


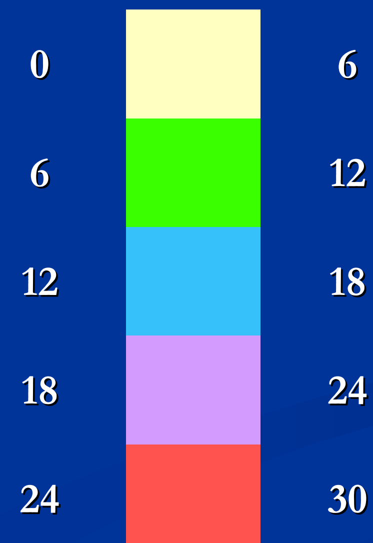
Frequency of Occurrence (30year)



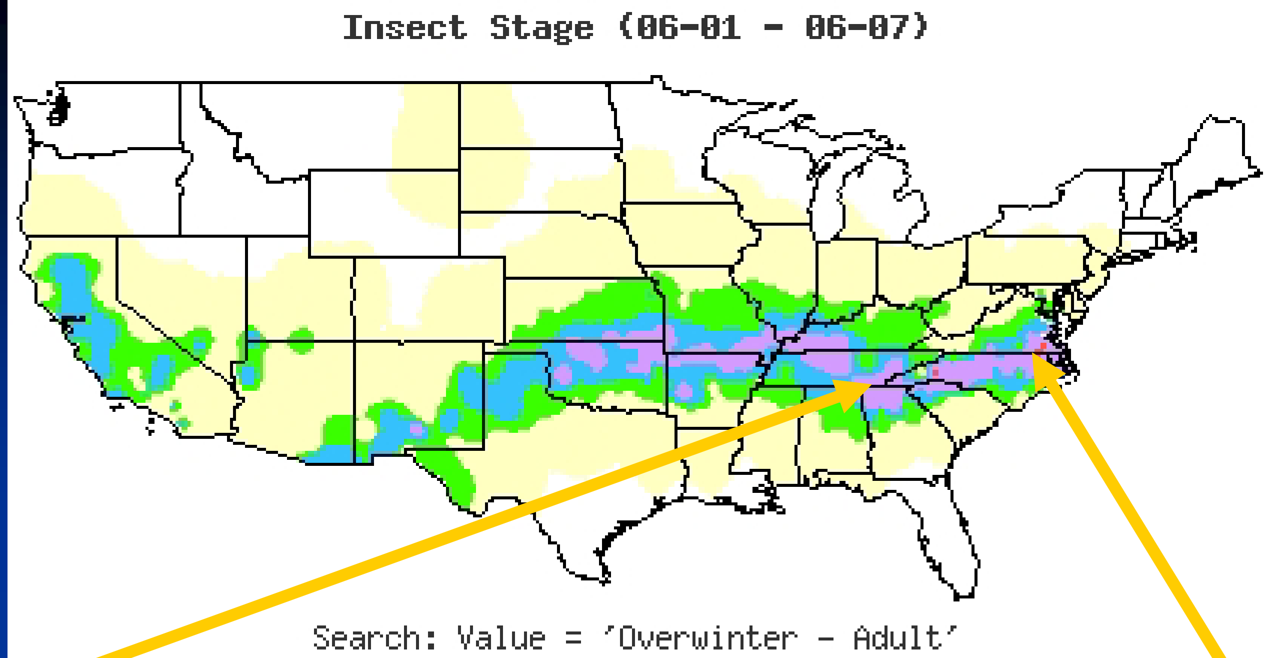
Adult beetles begin to emerge in central NC 3rd week in May (Fleming 1972)



Frequency of Occurrence (30year)



Beetles appear in central Virginia in last week of May- first week of June.(Fleming 1972)



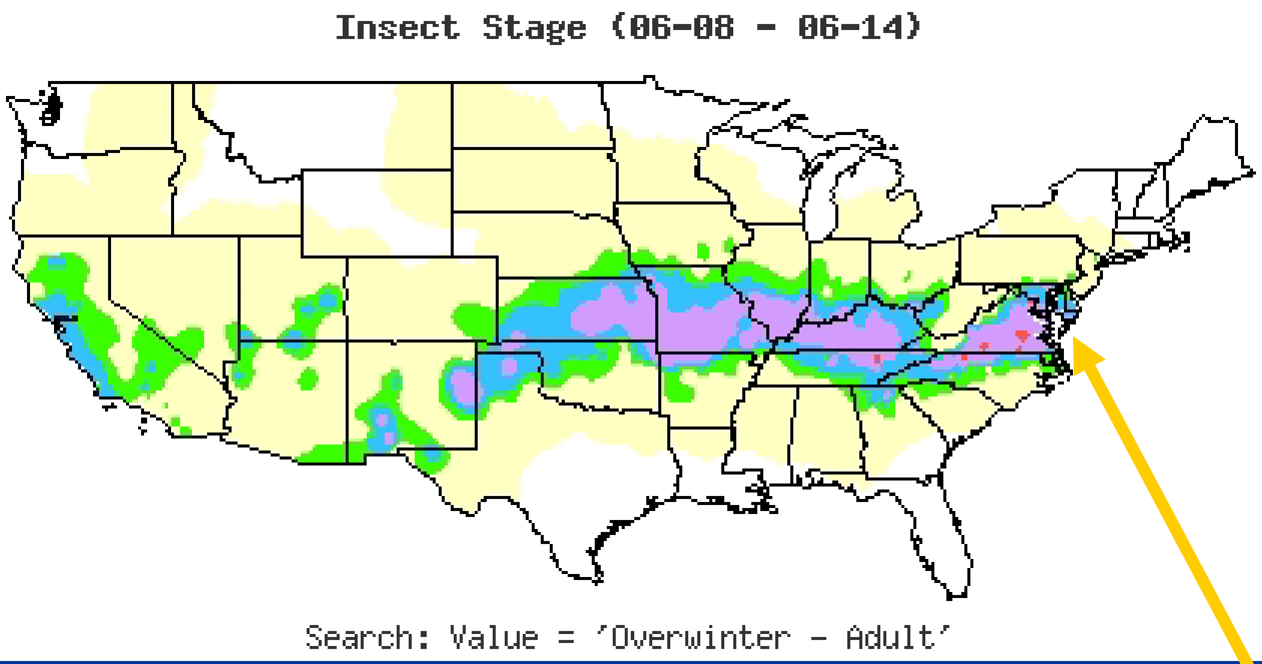
Mountainous Eastern TN beetles appear first week of June (Fleming 1972)

Beetles appear in central Virginia in last week of May-first week of June.(Fleming 1972)

Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

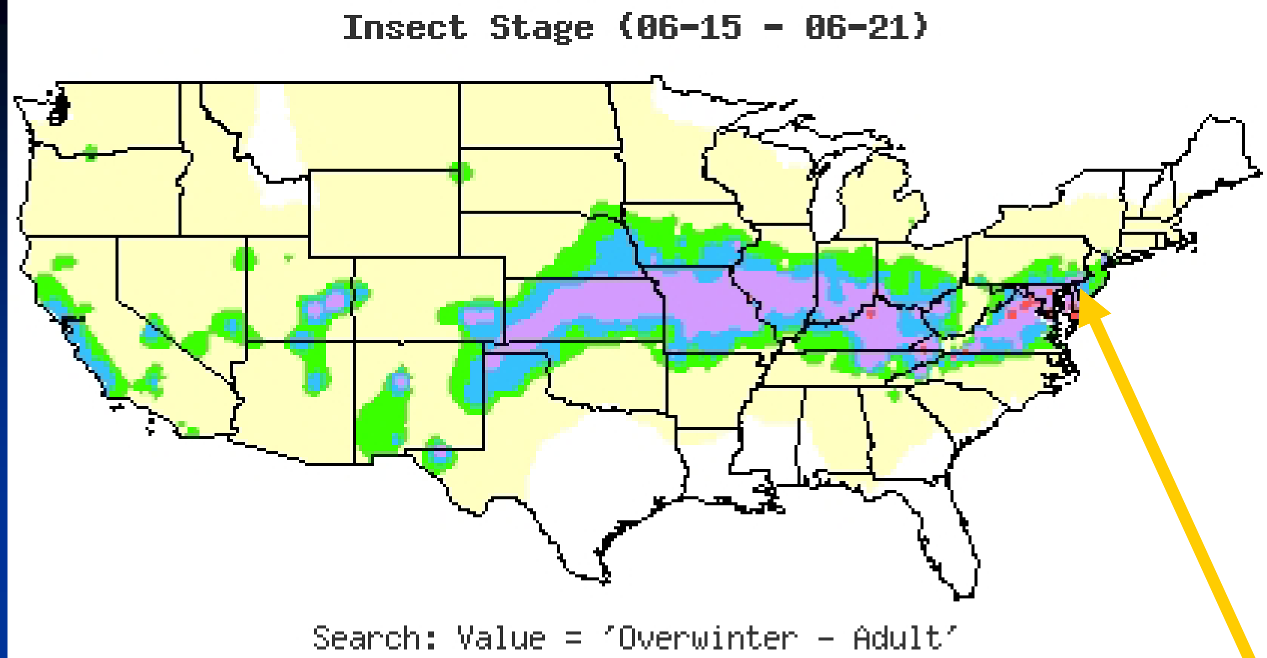
NAPPFAST



Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

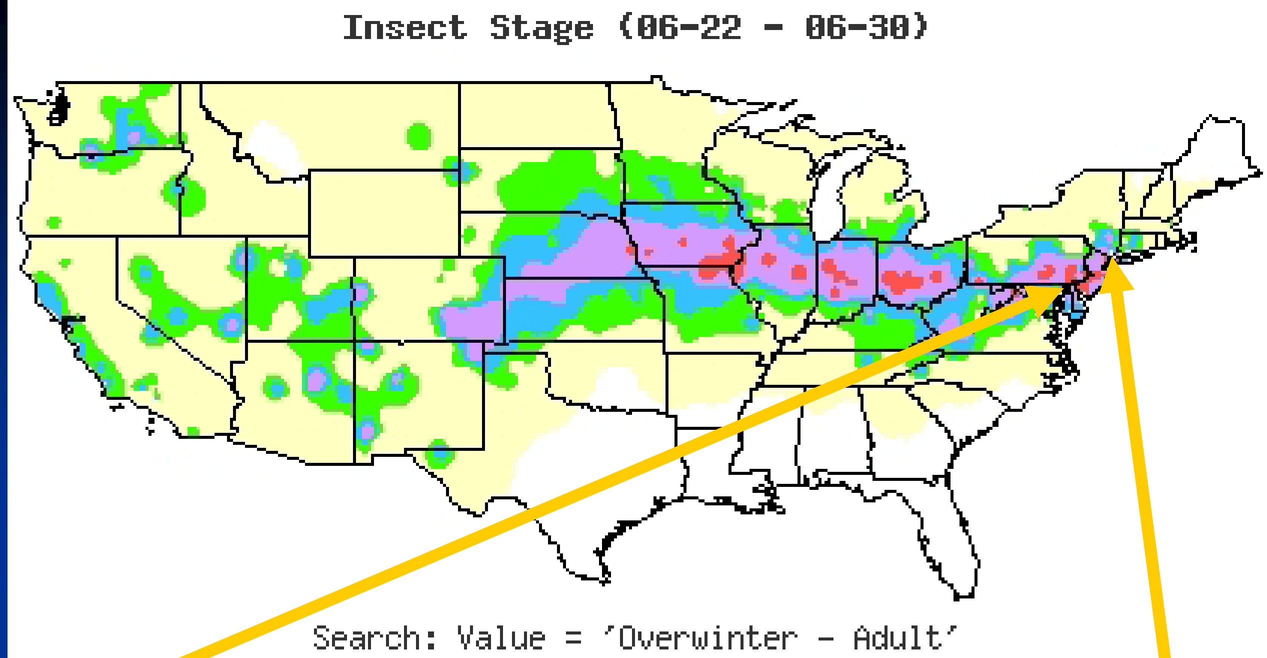
Adult beetles begin to emerge in Maryland & Delaware mid June (Fleming 1972)



Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

Adult beetles begin to emerge in Southern NJ and Southeastern PA in 3rd week of June (Fleming 1972)



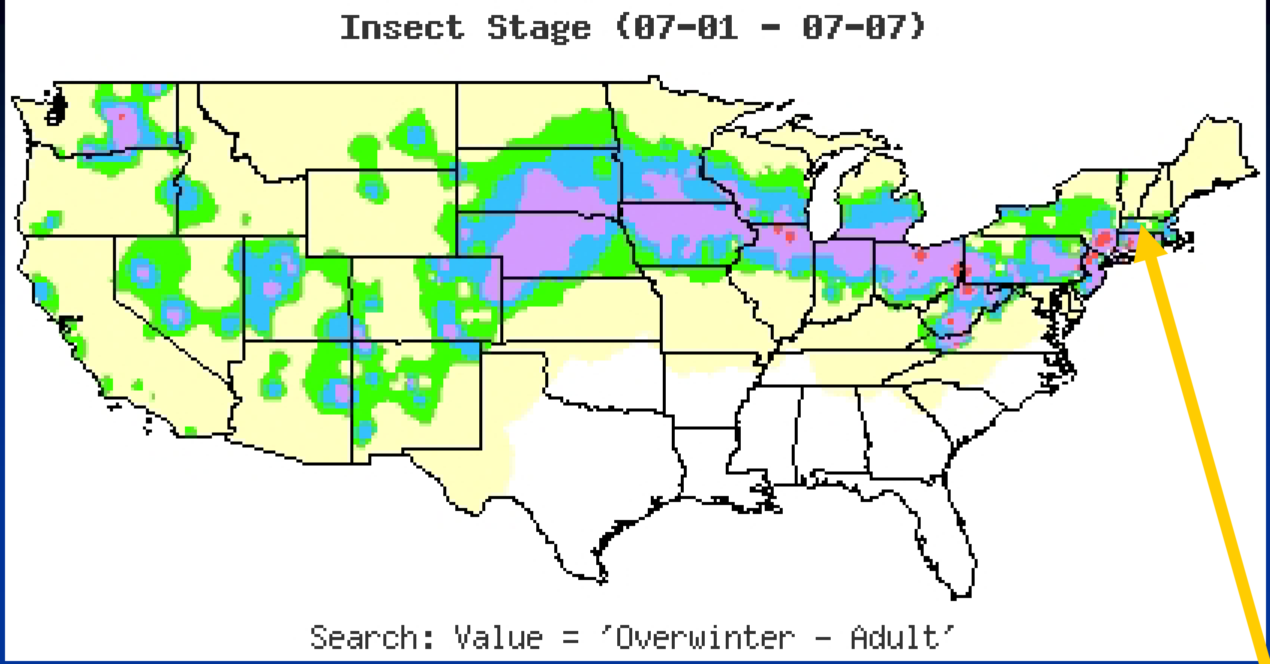
Emergence in mountainous regions of NJ and PA 1-2 weeks later (Fleming 1972)

Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

Emergence in Southeastern NY, CT, RI and Southern MA in last week of June (Fleming 1972)

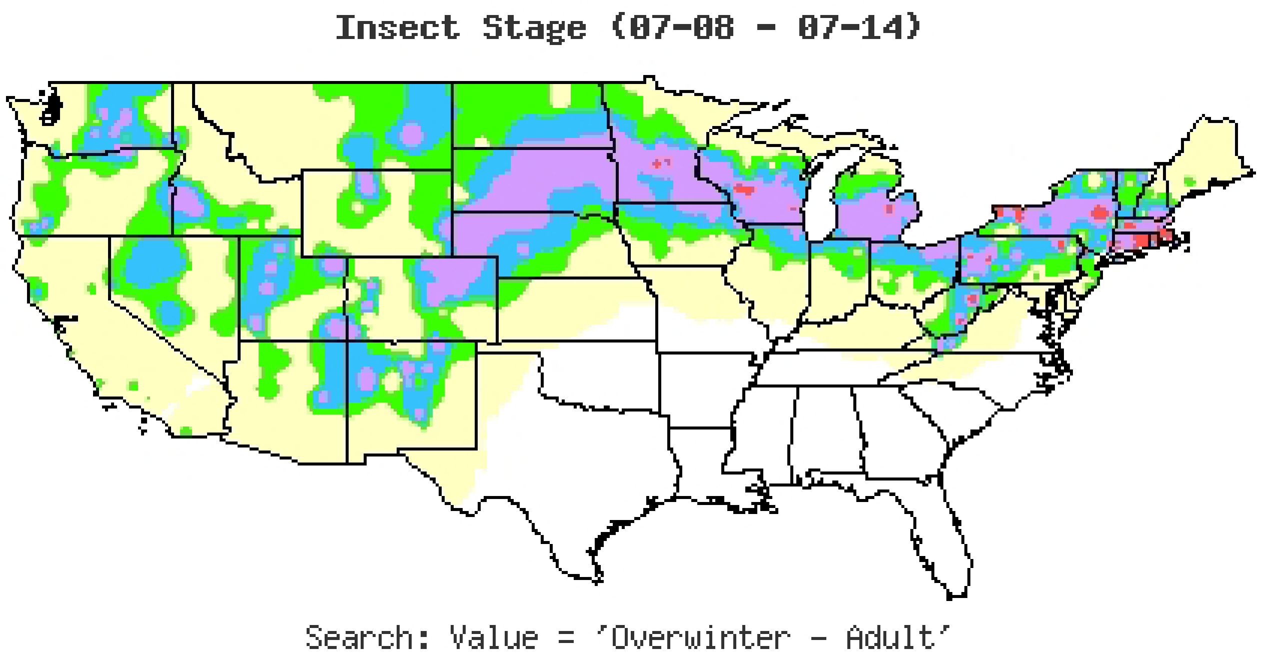
NAPPFAST



Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

Emergence begins in Southern NH and VT in first week of July (Fleming 1972)



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12	18
18	24
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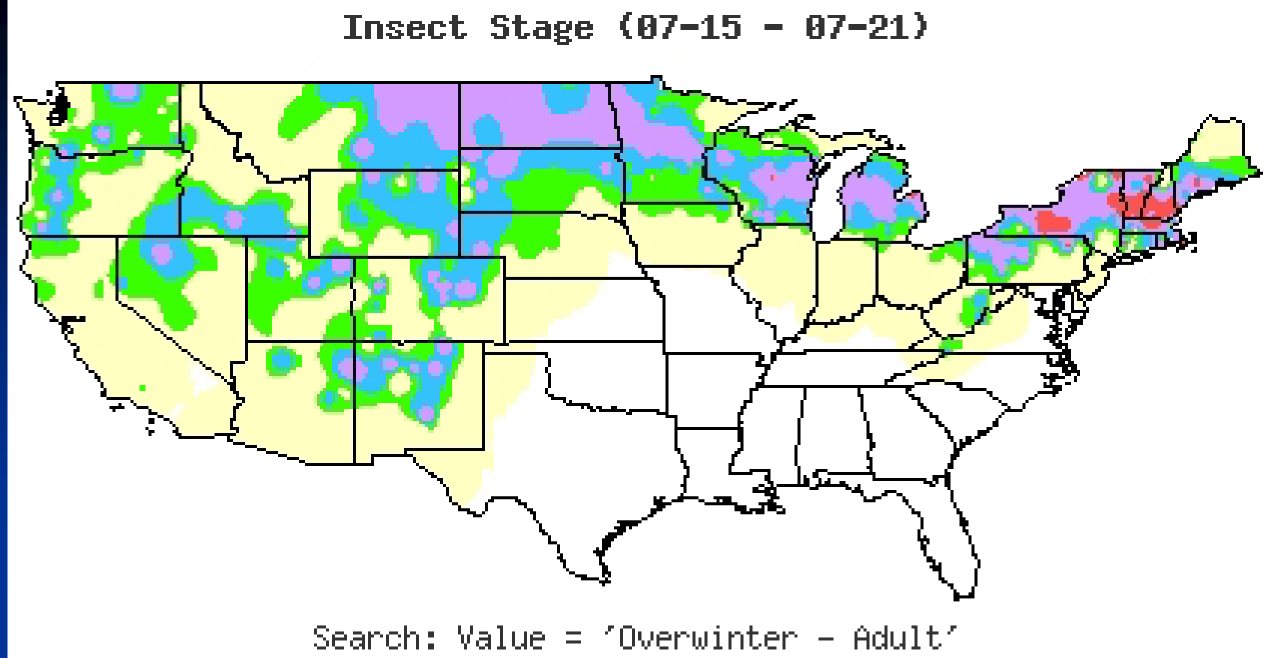


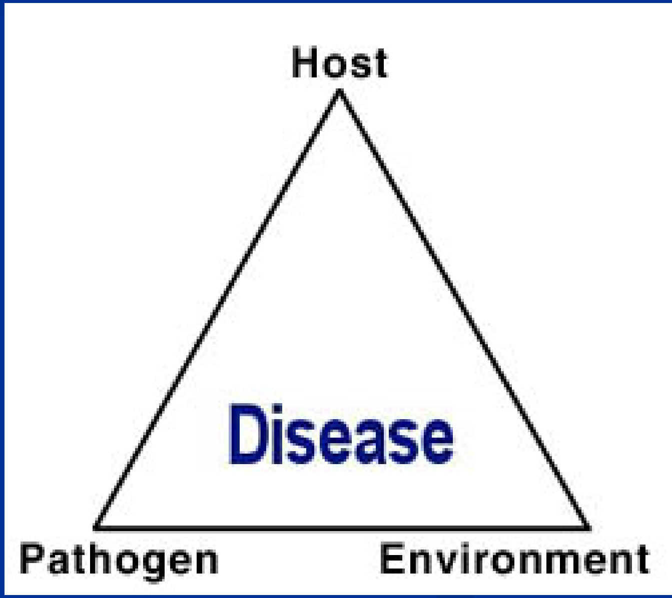
Frequency of Occurrence (30year)

0	6
6	12
12	18
18	24
24	30

NAPPFAST

Background Primer

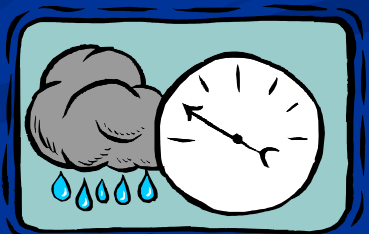
- Plant pathologist describe interactions between pathogen, host and environmental conditions as the disease triangle.



Generic infection model

Infection is often the rate limiting step in an epidemic because it requires moisture which is often limited in terrestrial environments

Infection can be modeled by a temperature /moisture response function - a mathematical function that describes the response of an organism to temperature and moisture

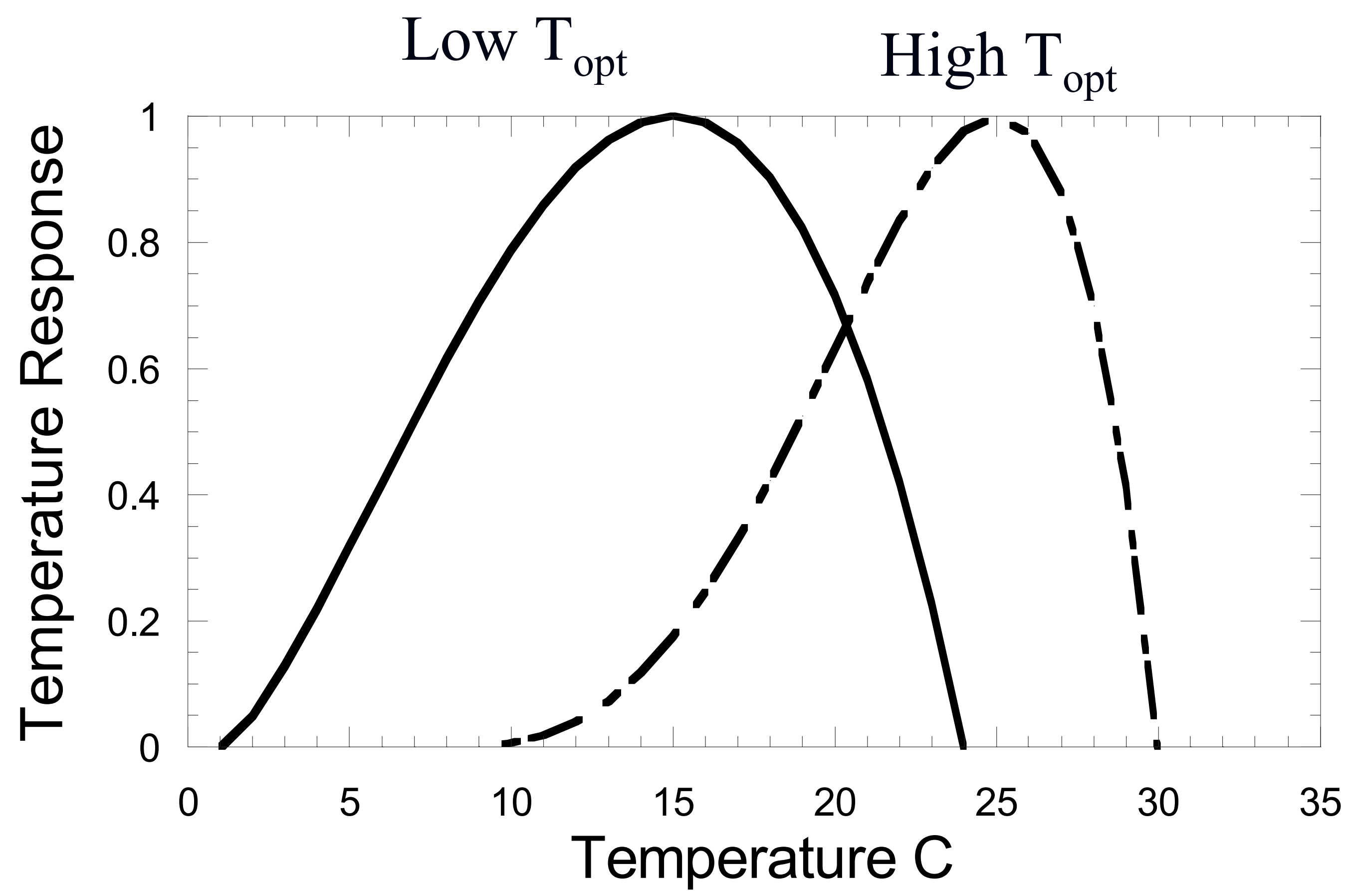


Parameters

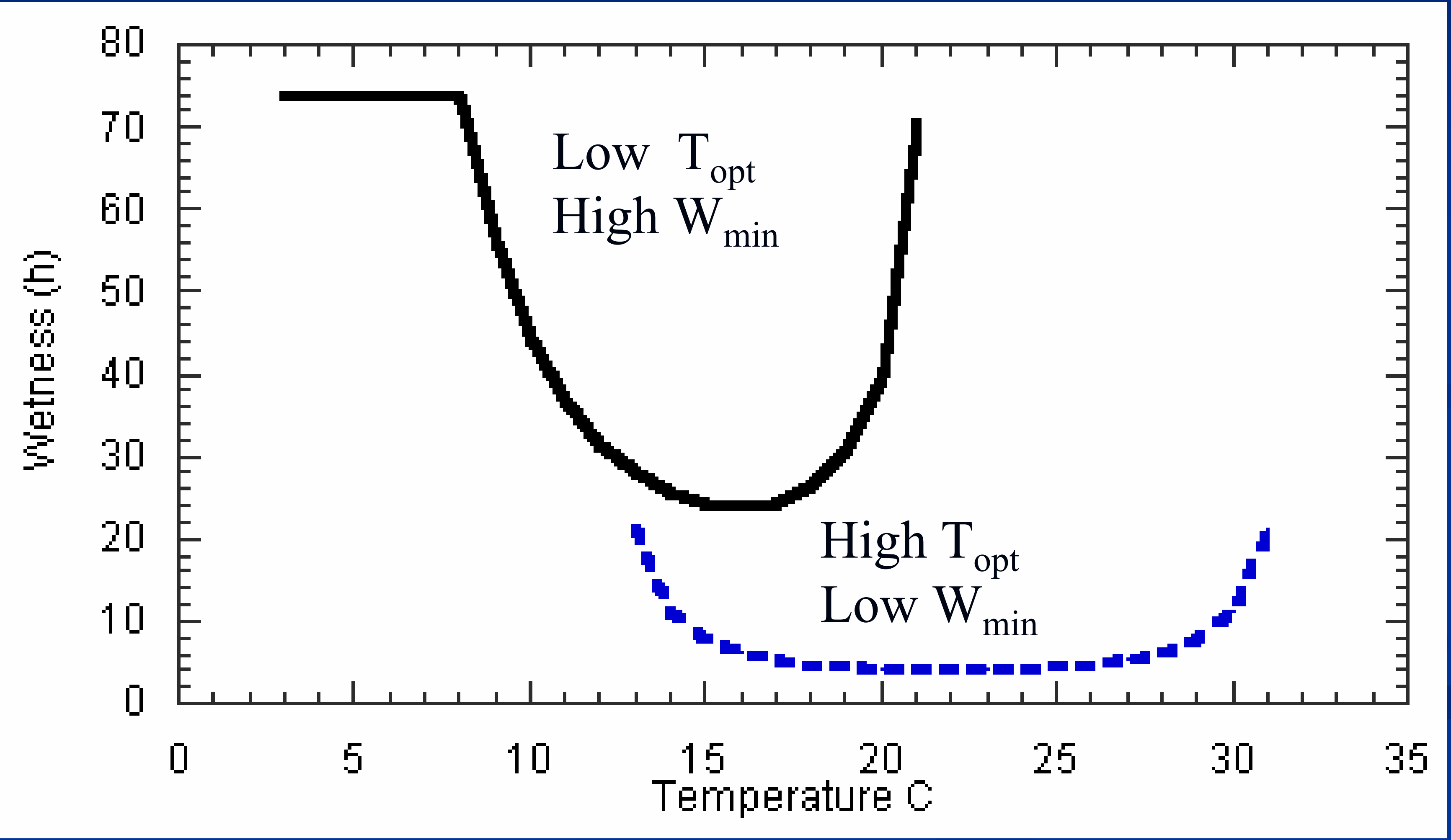
- T_{min} = Min. temperature for infection, ^{o}C,
- T_{max} = Max. temperature for infection, ^{o}C,
- T_{opt} = Opt. temperature for infection, ^{o}C,
- W_{min} = Minimum wetness duration requirement, h

Parameters established in laboratory studies

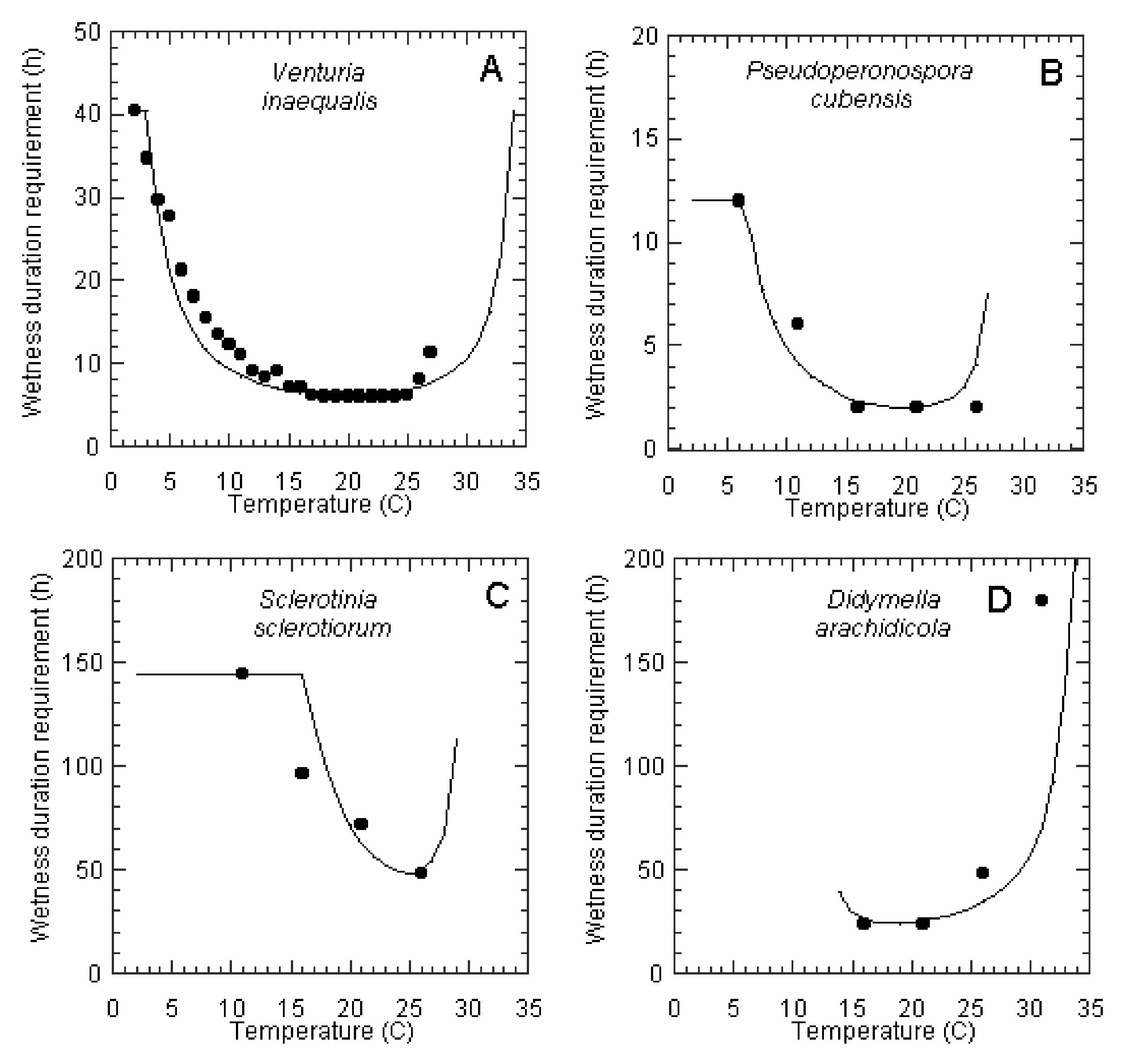
Temperature response function



Temperature moisture response function

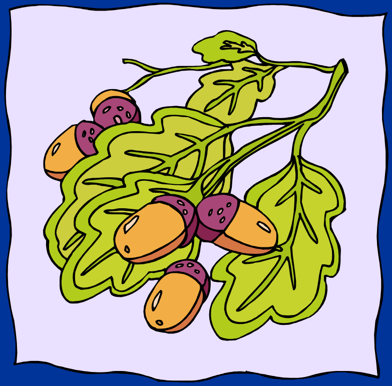


Examples of pathogens



Sudden Oak Death, *Phytophthora ramorum*

- Fungal disease in cool wet weather.
- Currently in Western US: California and Oregon



Source Ventana Wilderness Society

Model Parameters

- Temperature requirement

  3-28 C, 20 C optimum (Werres, 2001; Orlikowski, 2002).
- Moisture requirement

  12 hours for zoospore infection (Huberli,2003)
- Model description

  Unpublished infection model uses Wang et al. (1998) temperature response function scaled to a wetness duration requirement.

Model Name: rdm-sod-infection
Template: Generic Infection 1
Pest: --

Model Setup

Begin Day (mm-dd): 01-01
End Day (mm-dd): 12-31
Infection Level Lower Limit: 0
Infection Level Upper Limit: 1

Setup Variables

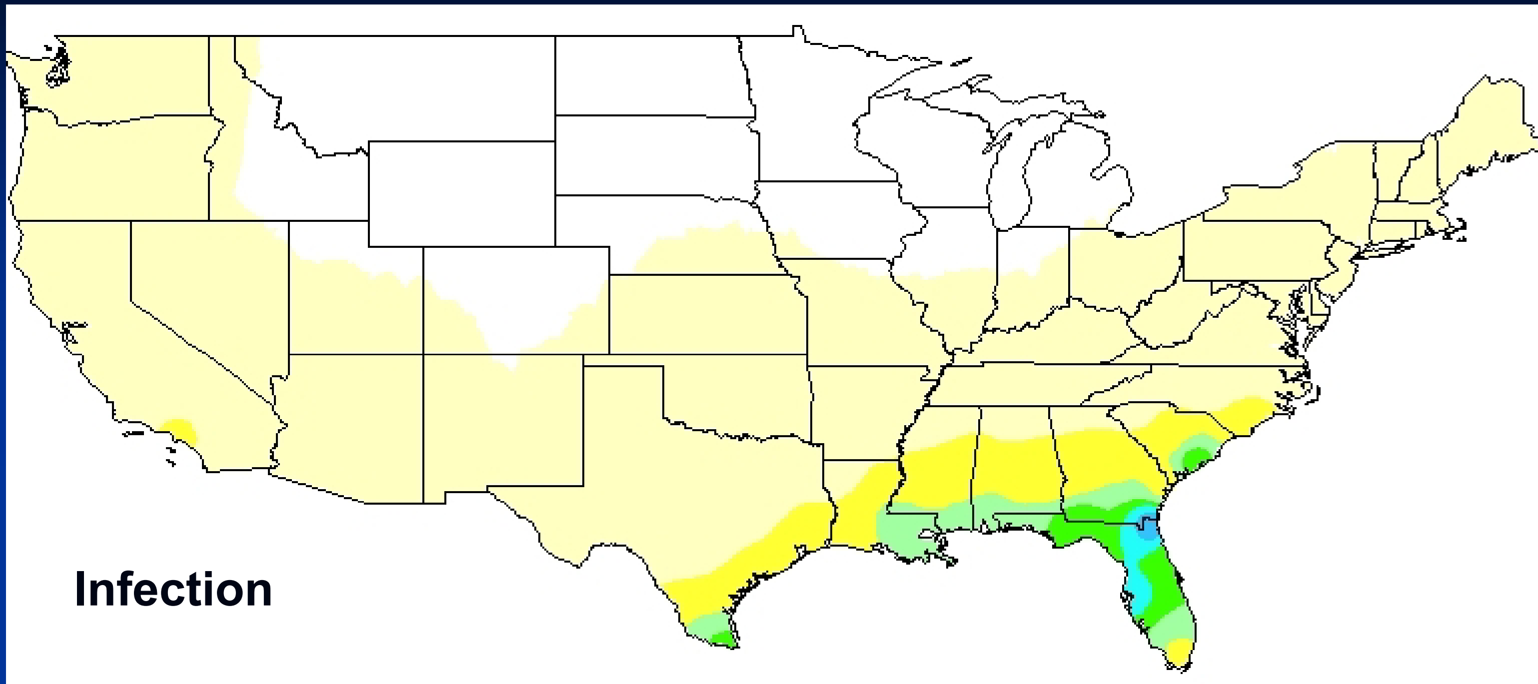
Variable	Unit	Min	Opt	Max
Air Temperature	C	3	20	28
Leaf Wetness	hrs	12		

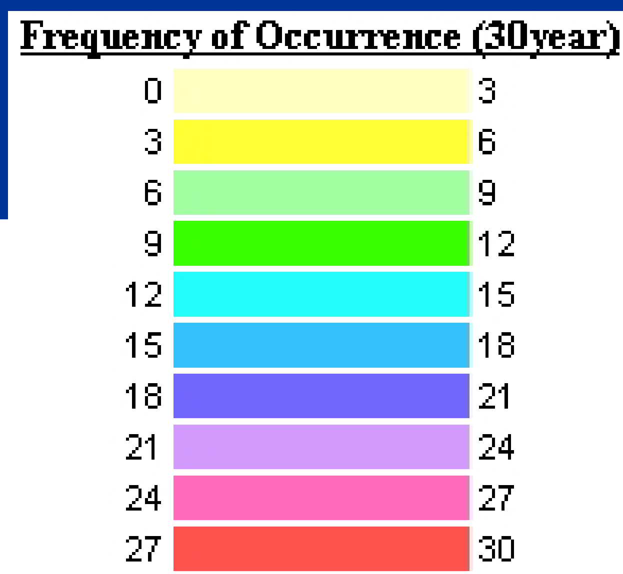
Setup Output

Name: Infection Level   Level +   Level -   ☑ Accumulate

	Low		High		Text	Color	R	G	B
1.	>	<=	0.9999	===>	Nil		0	0	255
2.	> 0.9999	<=		===>	Yes		255	0	0

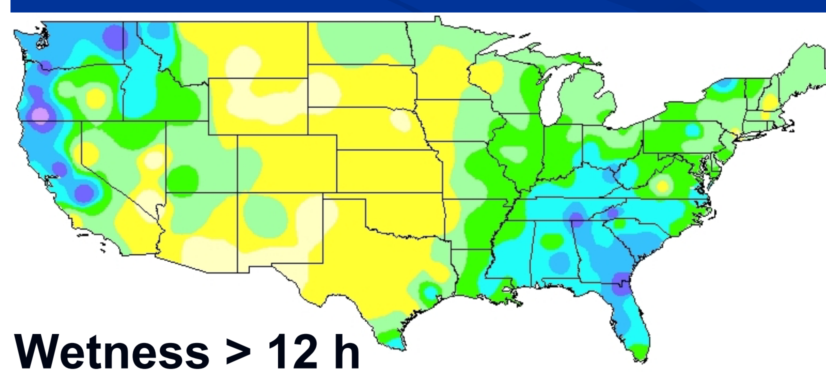
January 1



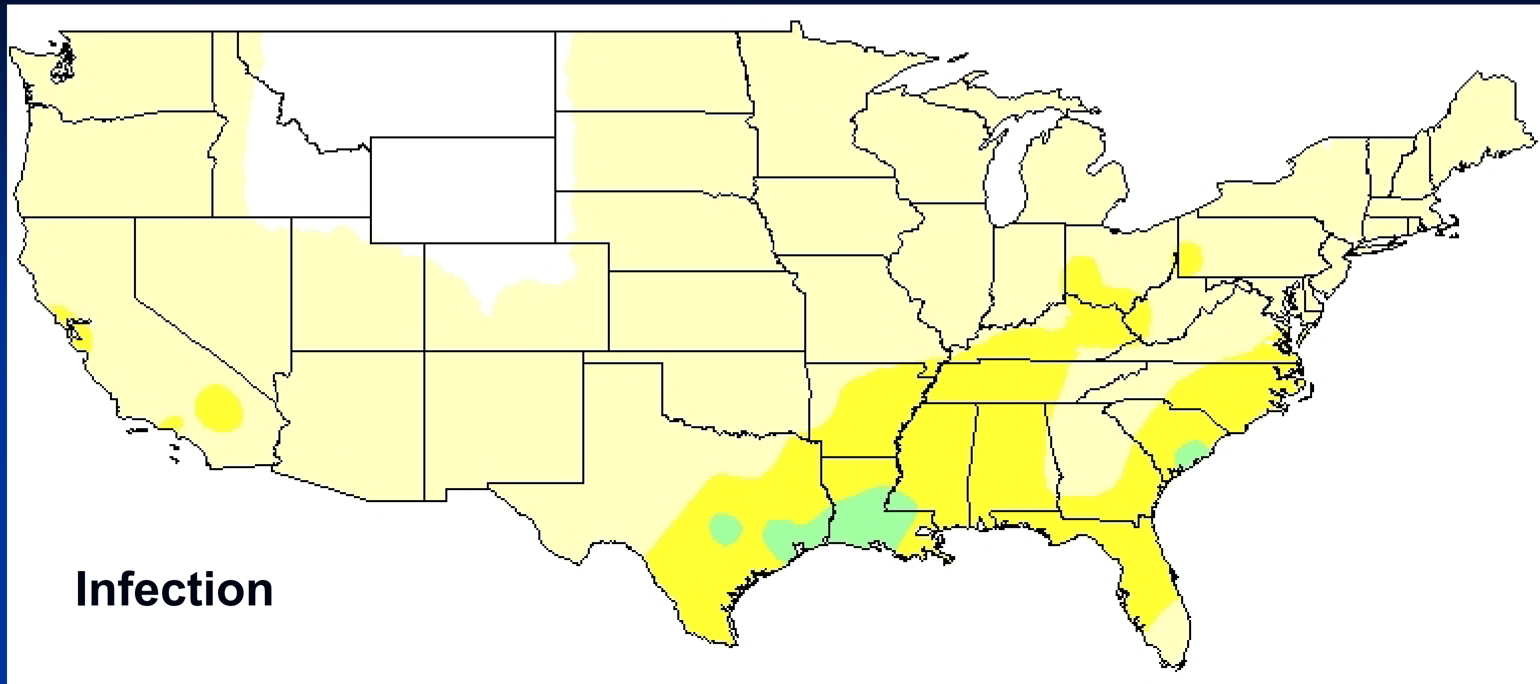


Sudden Oak

Death



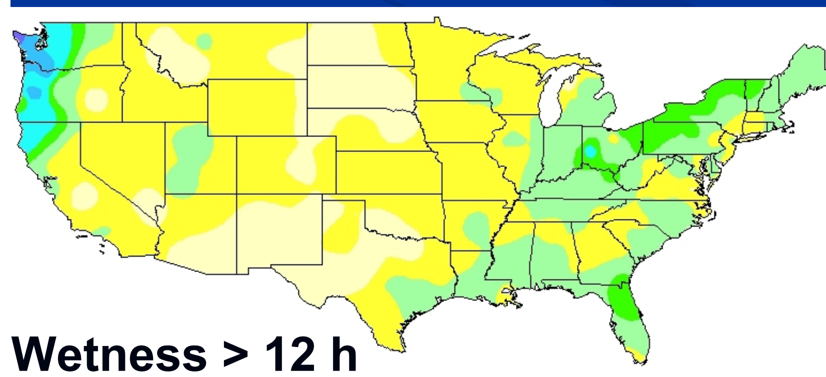
April 1



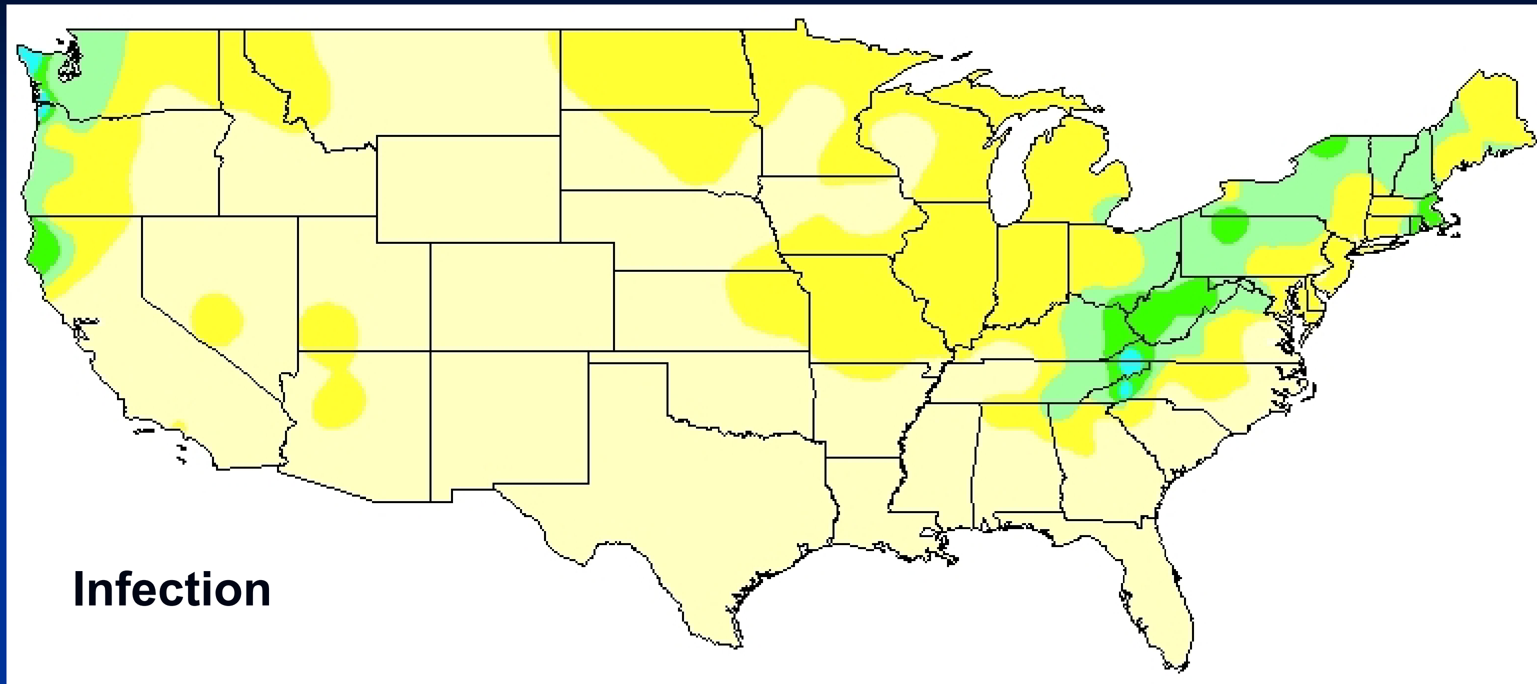
Frequency of Occurrence (30year)

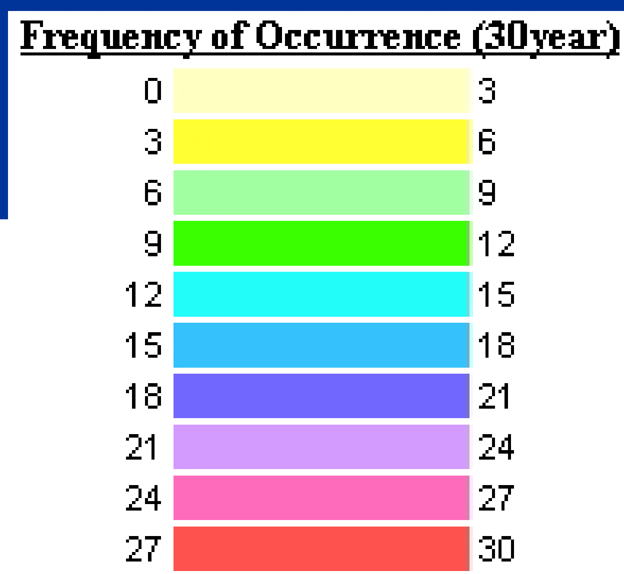
0	3
3	6
6	9
9	12
12	15
15	18
18	21
21	24
24	27
27	30

Sudden Oak Death

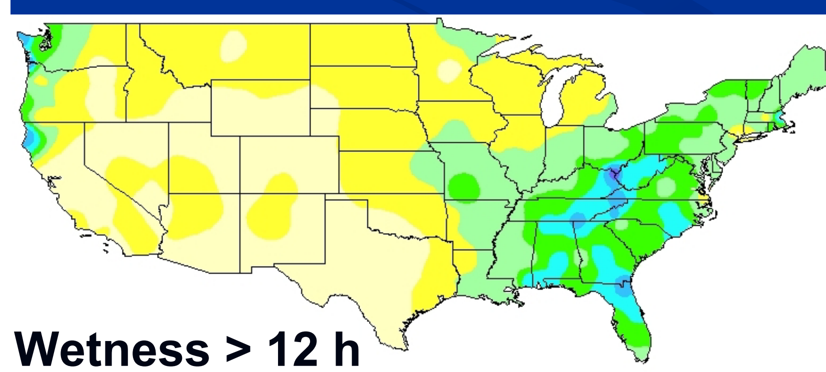


July 1

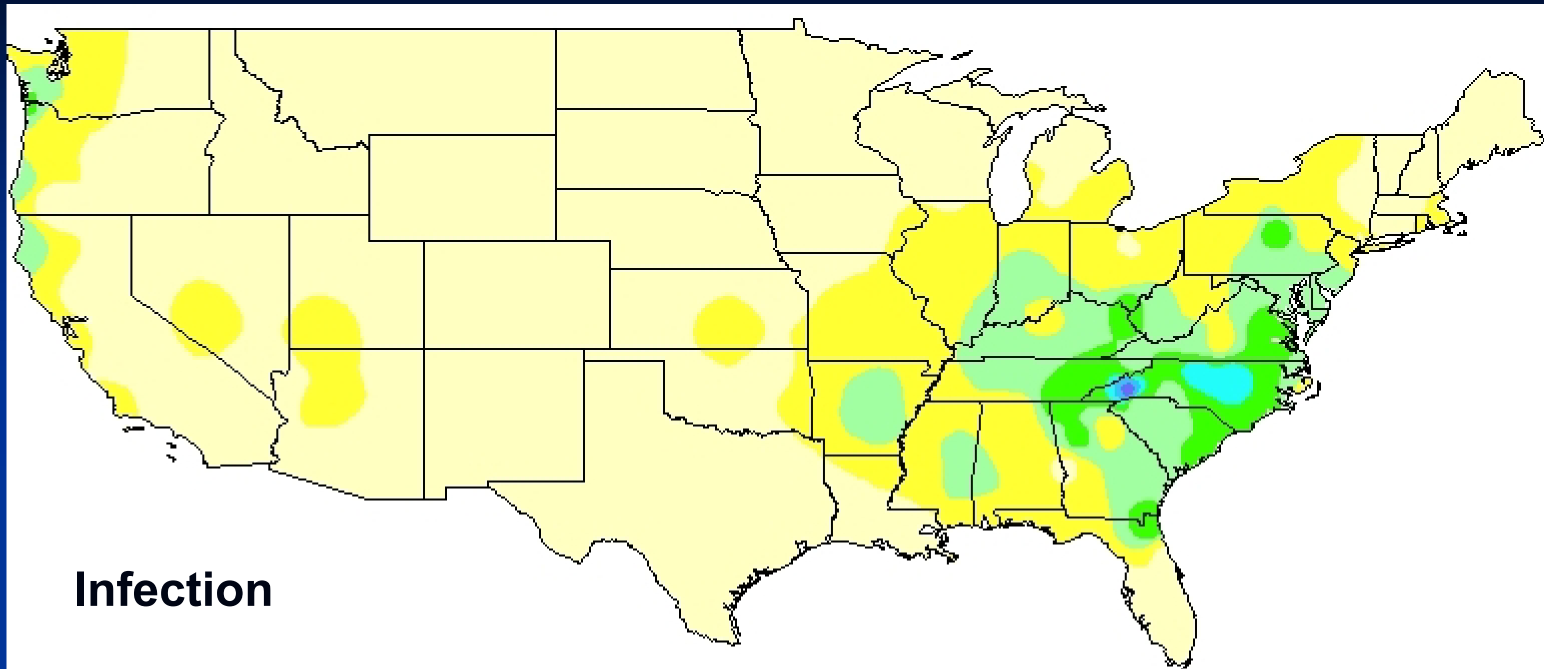




Sudden Oak Death



October 1



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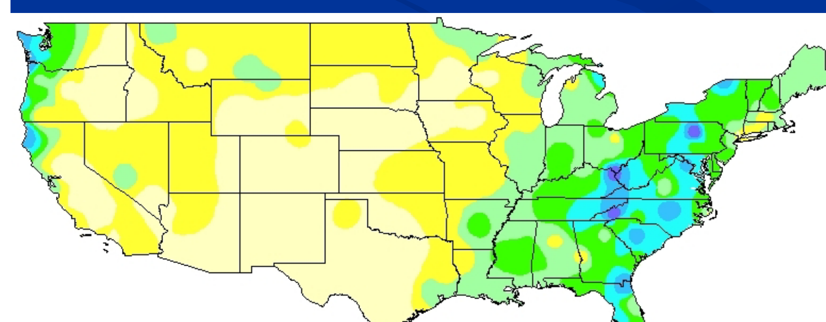
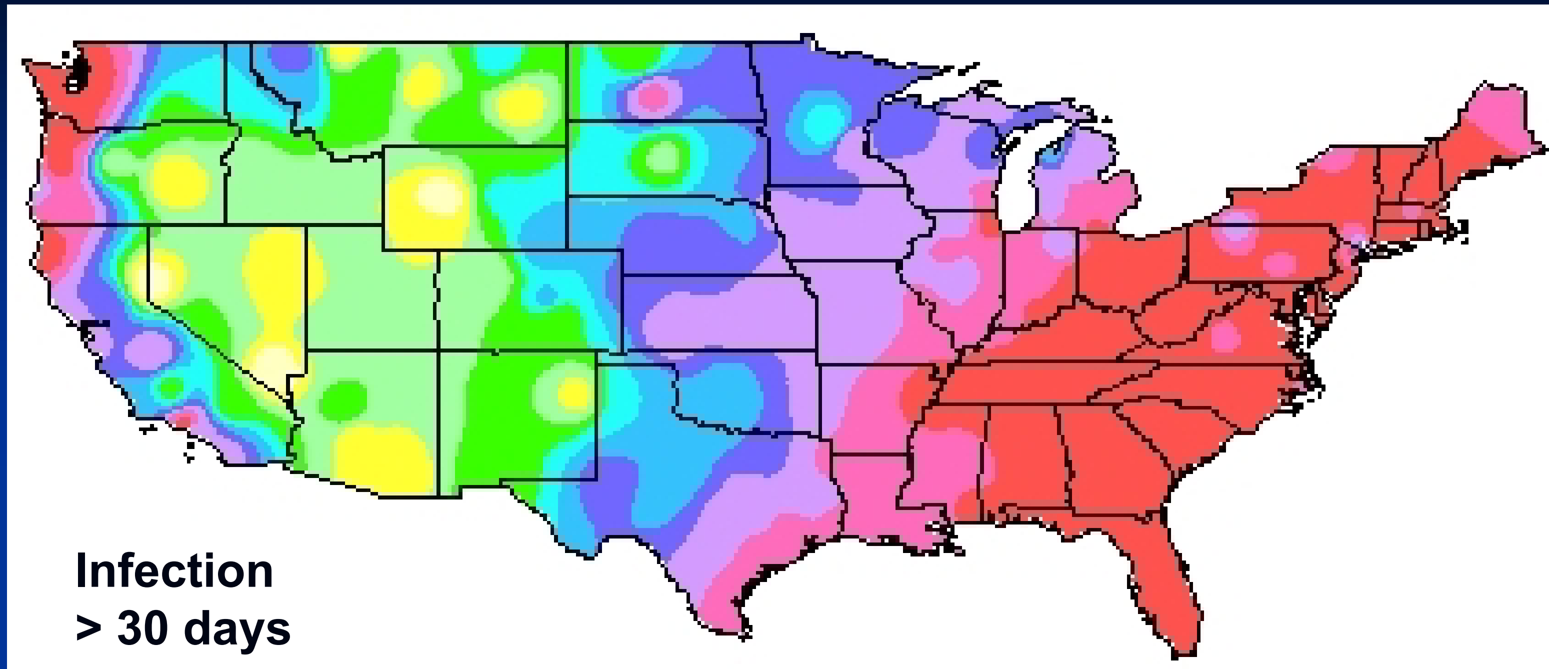
Sudden Oak

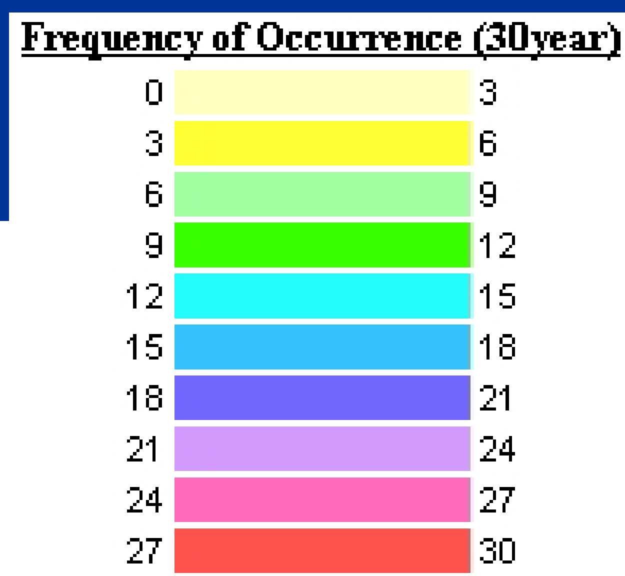
Death



Wetness > 12 h

Year

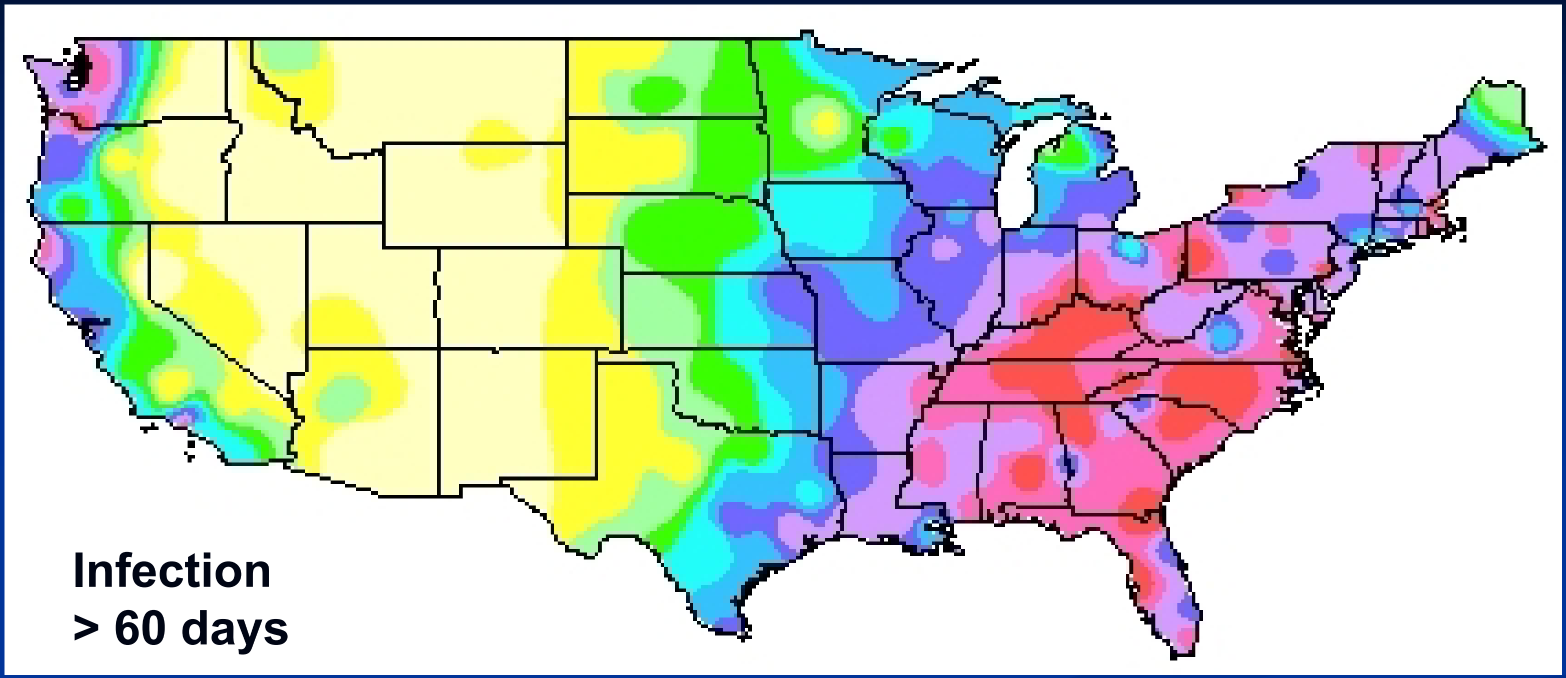


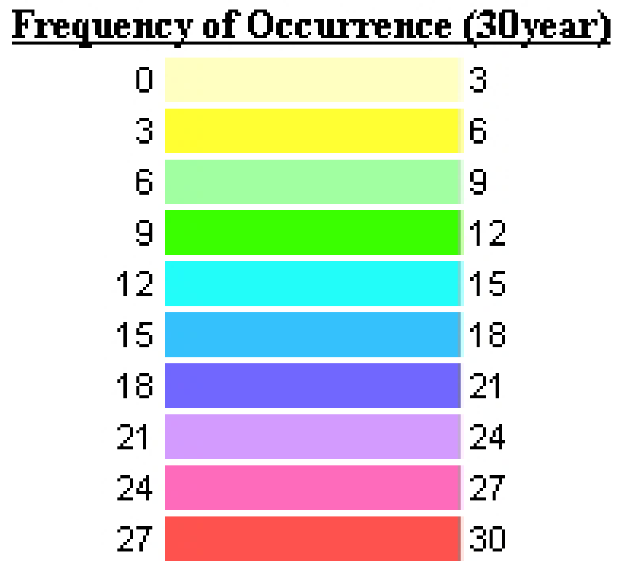


Sudden Oak

Death

Year

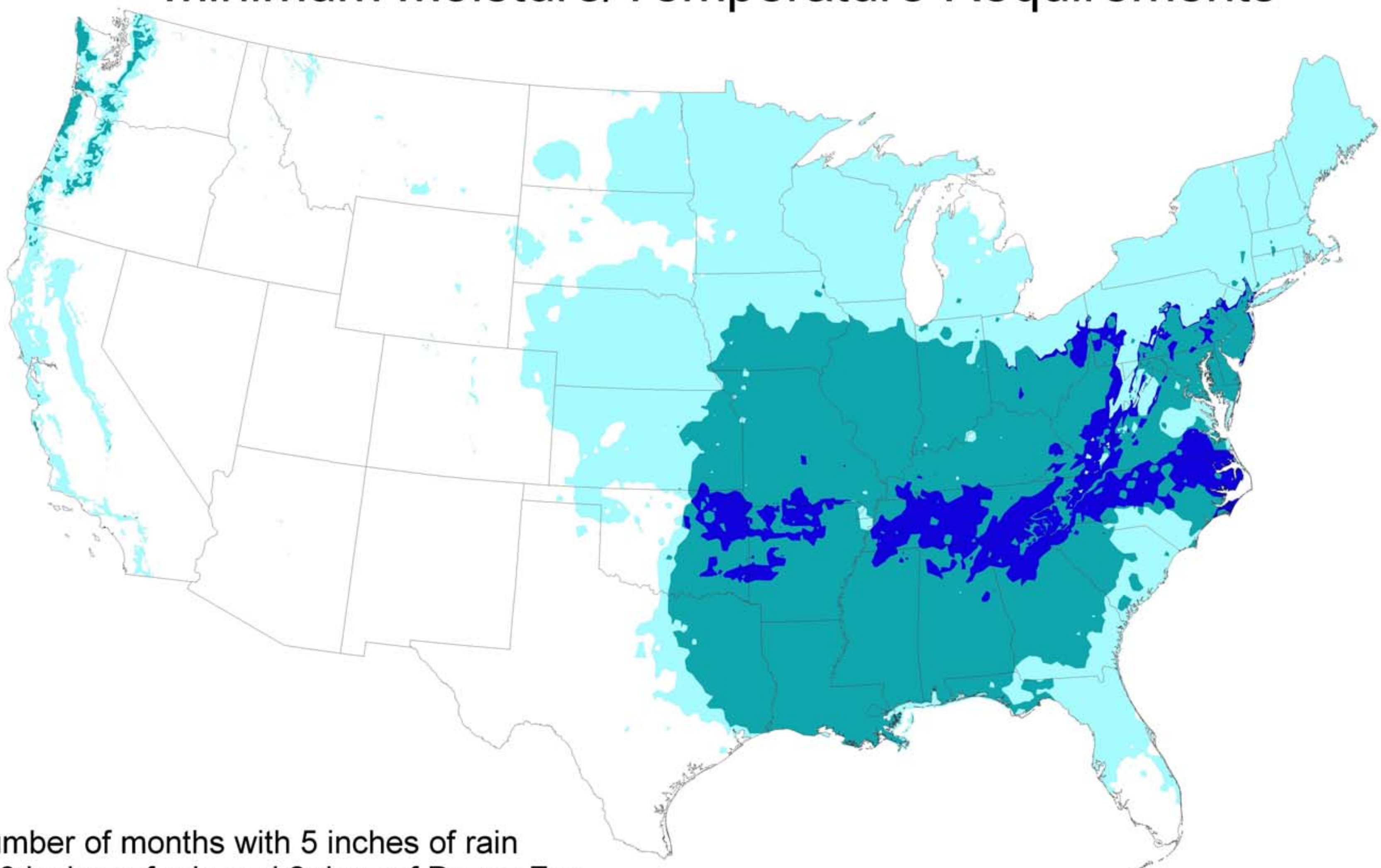




Sudden Oak

Death

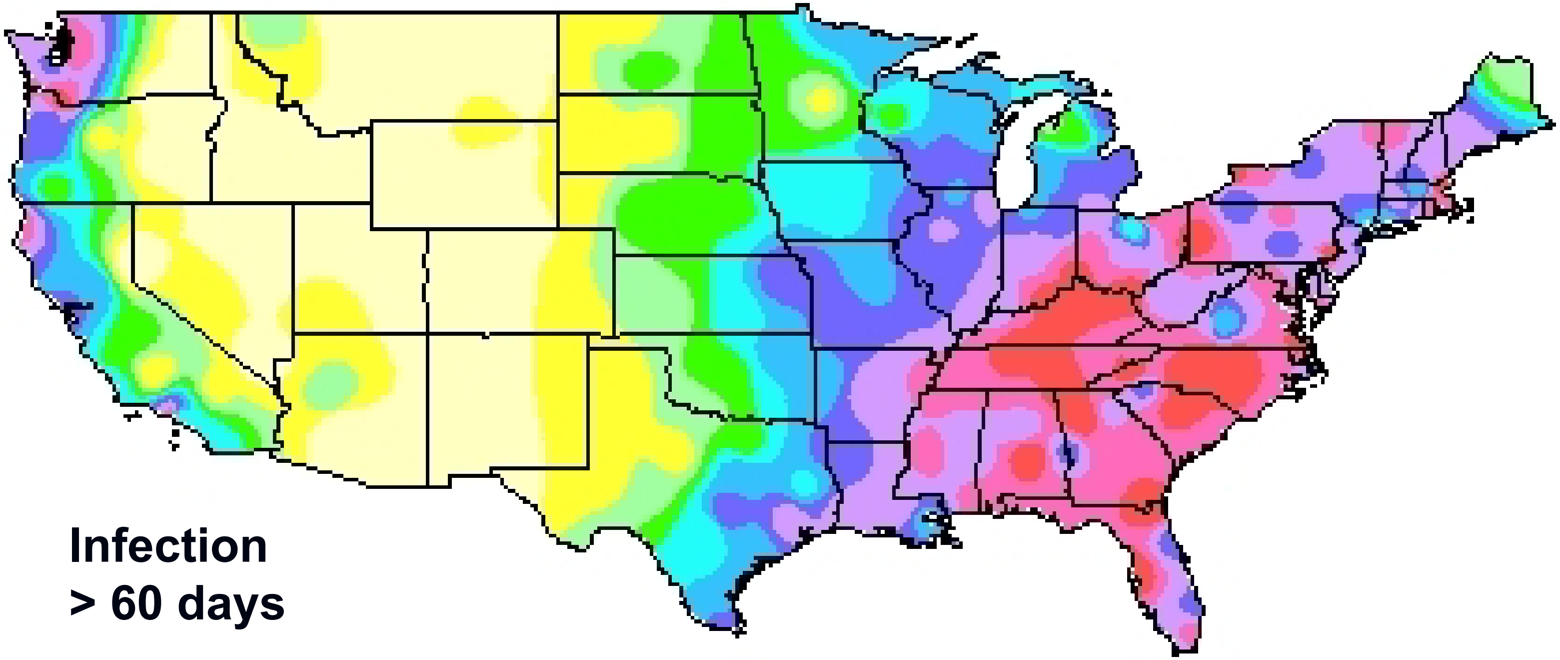
Minimum Moisture/Temperature Requirements



Number of months with 5 inches of rain
or 3 inches of rain and 2 days of Dense Fog
and temperature is between 60 and 80 degrees F.
(Source: National Climate Atlas)

0
1
2
3

Smith, USDA-FS



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24		27
27		30

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(Source: National Climate Atlas)

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1
2
3

Smith, USDA-FS

SOD Summary

- ‘Seasonal snapshots’ show relative infection risk for different locations and seasons.
- Maps need interpretation with respect to forest health and species composition.
- The methodology provides an alternative approach to the Smith method.
- Once international data becomes available it may be possible to pursue additional model validation.

Generic Disease Model

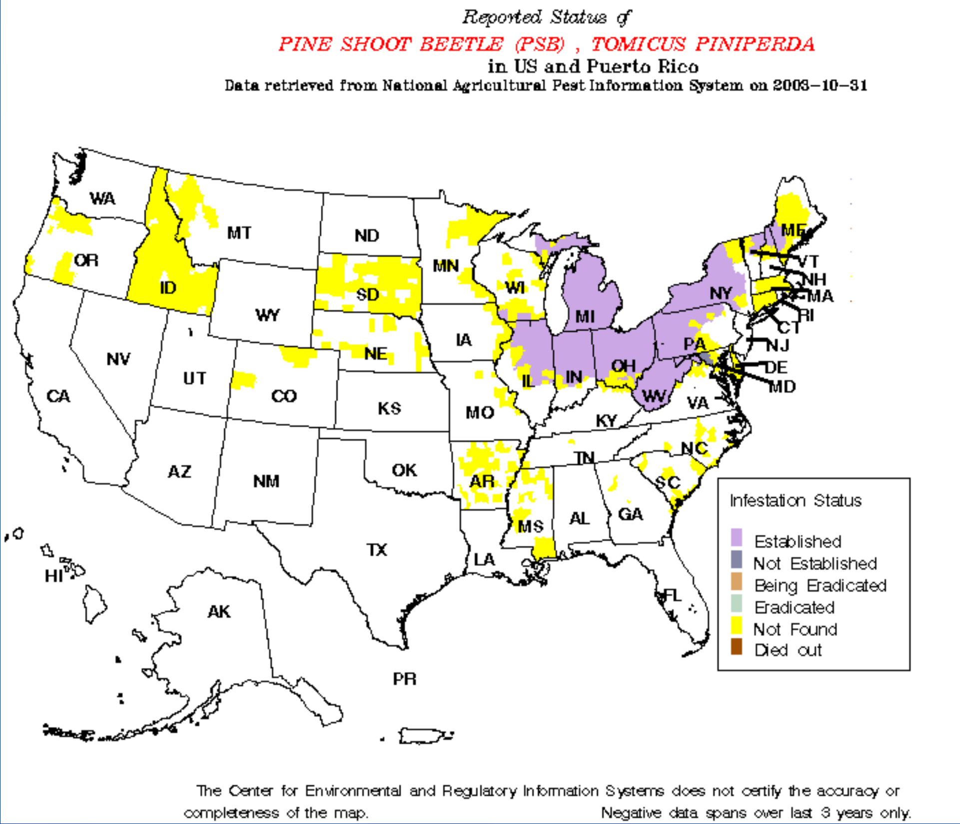
- Allows for construction of many different models using simple logical and mathematical equations:

  (X>A, X and Y, X or Y, X and (Y or Z), X≥A and X≤B, A* exp(B * X), etc.)

- Some examples used to date are: temperature exclusions (high and or low lethal temperatures), frost free days, and emergence dates

Pine Shoot Beetle (PSB), *Tomicus piniperda*

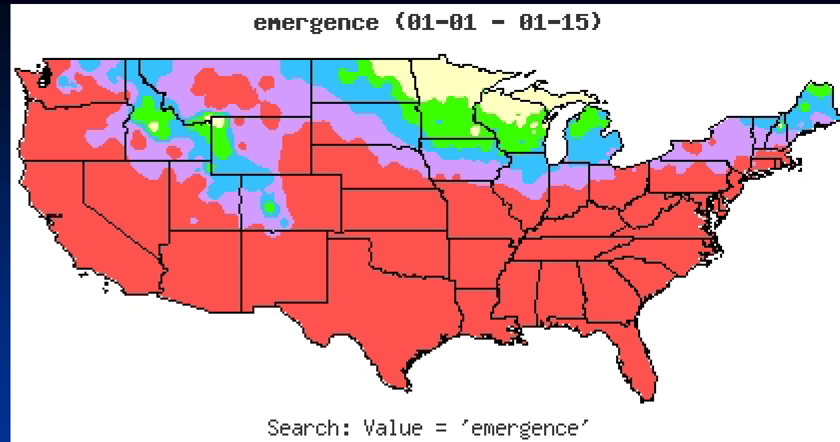
- Overwinters as adult, can emerge as soon as temperatures reach 50-54 F
- Emerges over a relatively short period of time
- Important to have traps out in time but not too early



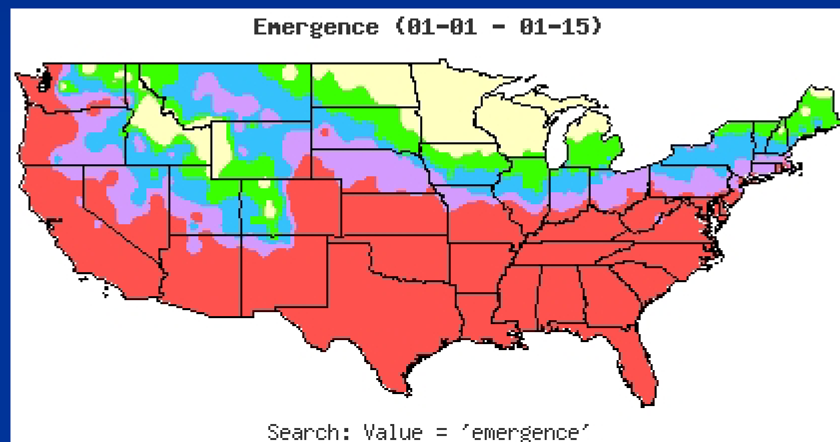
http://www.ncrs.fs.fed.us/4401/focus/climatology/tomicus/

PSB January 1-15

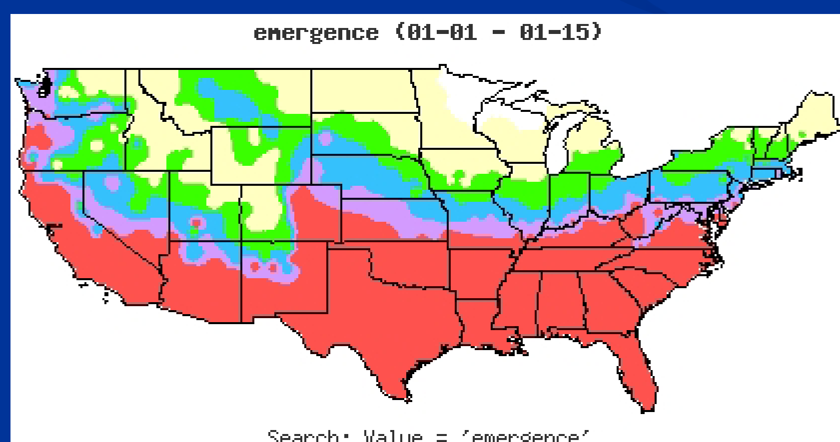
> 40 F



> 45 F



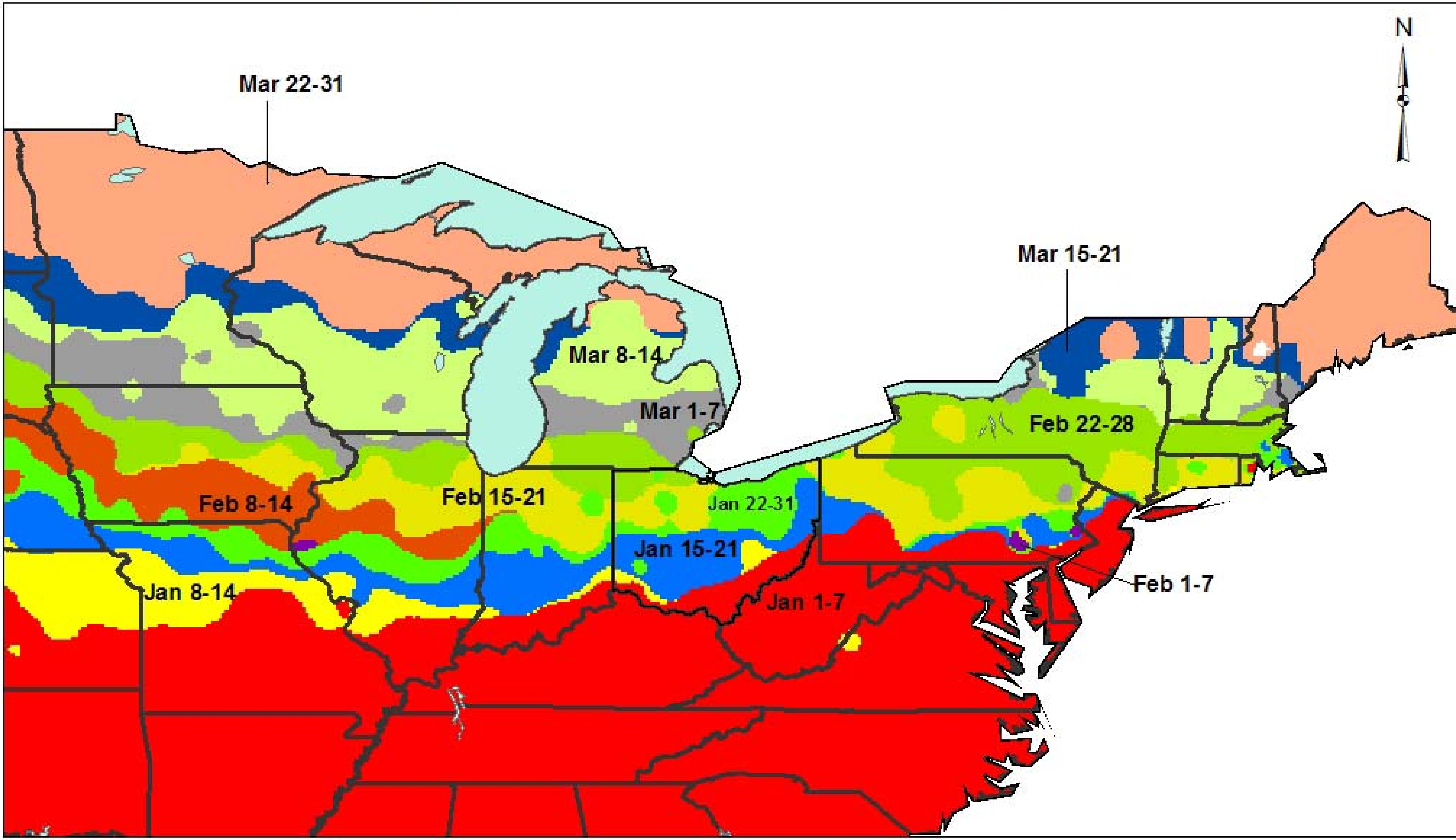
> 50 F



Frequency of Occurrence (30 year)

0	6
6	12
12	18
18	24
24	30

Predicted emergence dates for Pine Shoot Beetle, *Tomicus piniperda*, based on at least 2 days maximum temperature above 50 F (10C) in 7-10 day period with occurrences in 24 of 30 years.



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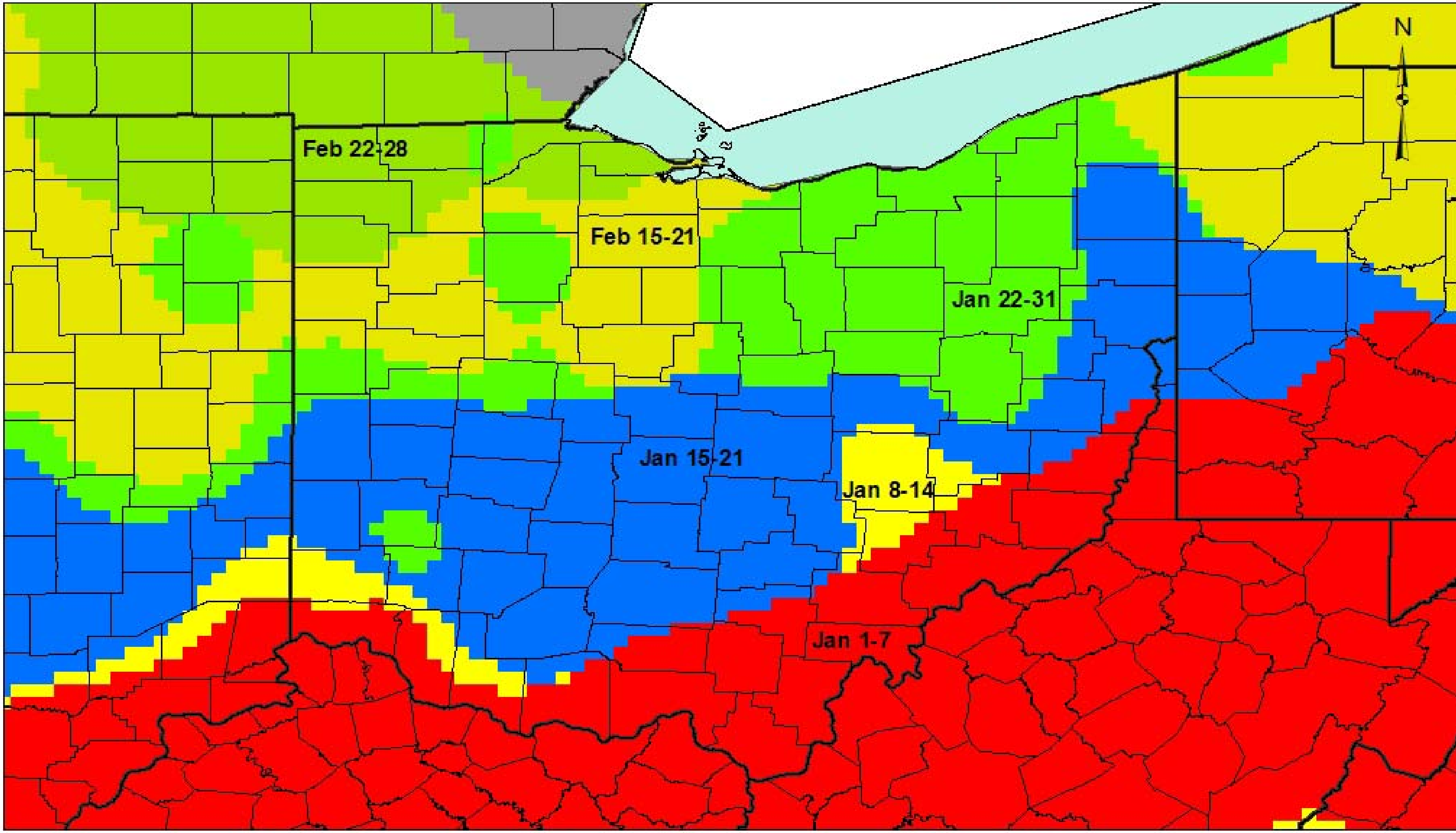
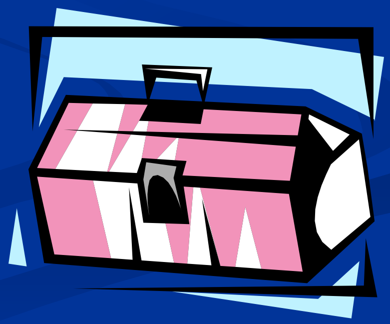


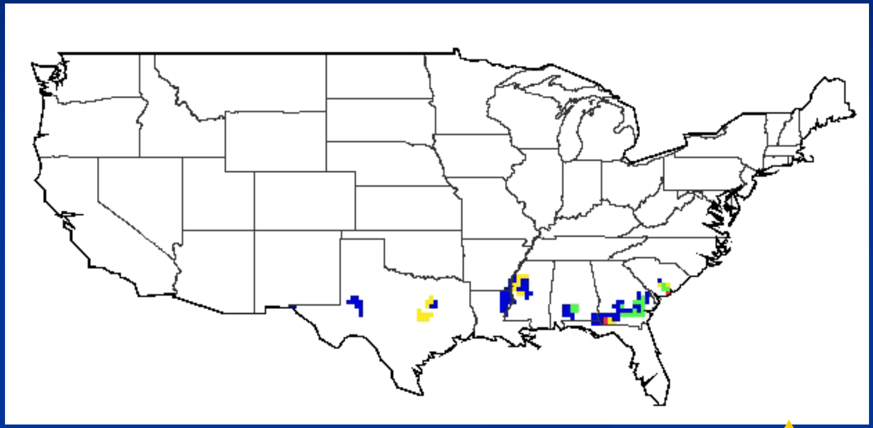
Benefits of NAPPFAST

- Ability to create desired models and rapidly provide information for local or nationwide areas: as quickly as a few hours
- Relatively small amount of information required to construct models
- A tool to assist CAPS personnel

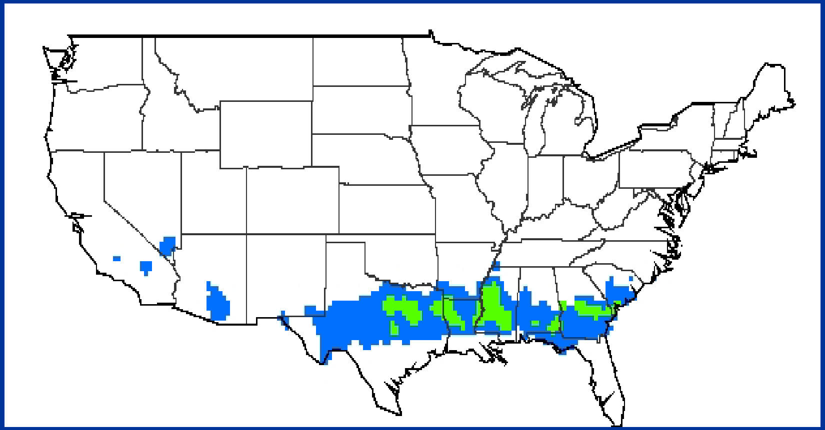


Additional Map Features

- Maps are geo-referenced and can be exported into ArcGIS for further customization

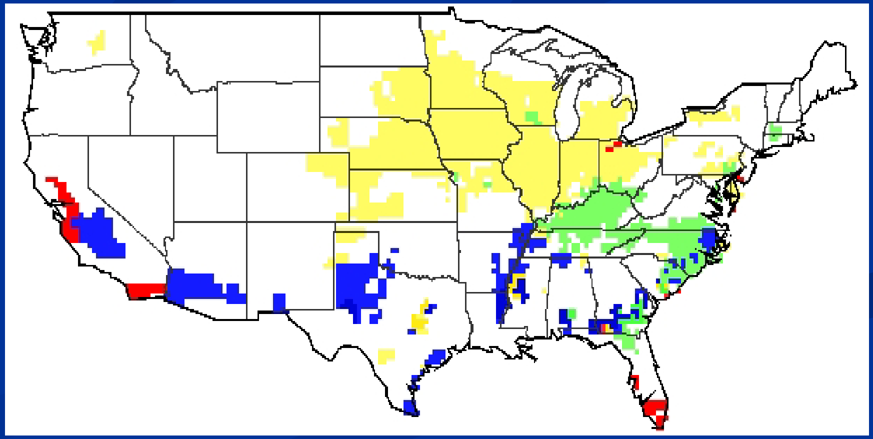


Union of occurrence and crops



Occ. of 1st gen. adult *H. armigera* June 1-7

+

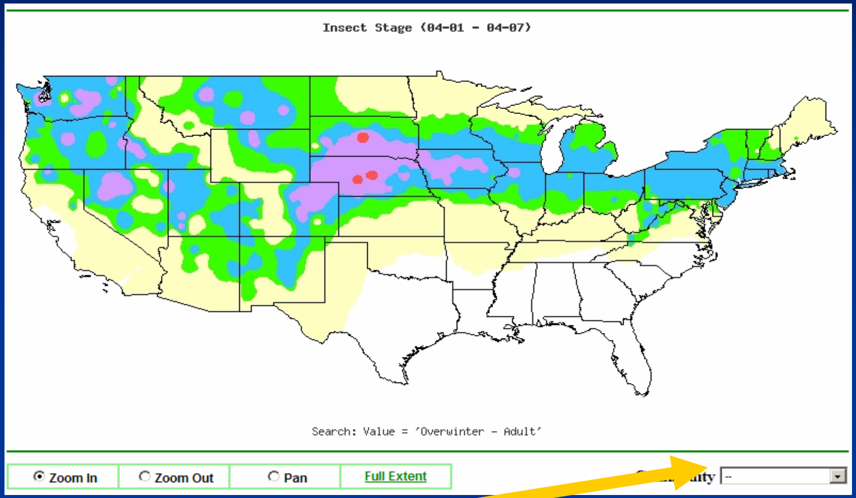


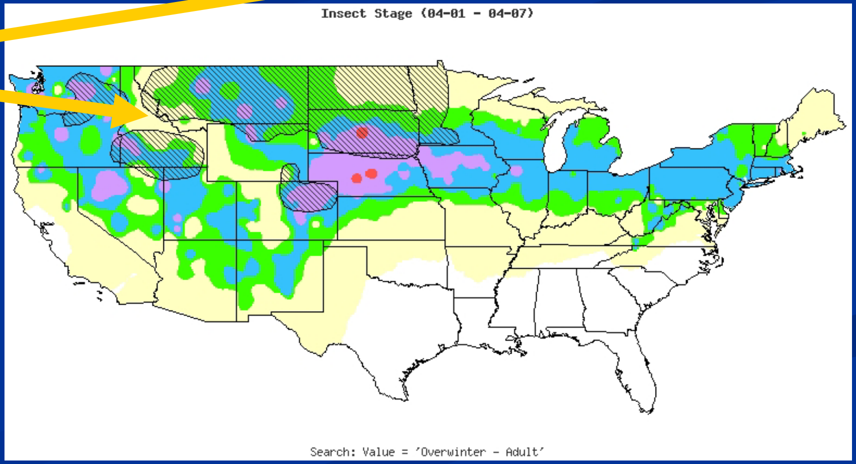
Major growing areas of corn, tomatoes, cotton and tobacco

Map features

- Zoomable after double click enlargement
- Ability to overlay major crop production information

(*O. melanopus* adult and minor spring wheat April 1-7)





Models Completed to Date*

Insects

- Japanese Beetle
- Cereal Leaf Beetle
- Old World Bollworm
- European Grapevine Moth
- Leek Moth
- Swede Midge
- False Codling Moth

Diseases

- Wheat Rust
- Downy mildew of corn
- Sweet Orange Scab
- Citrus black spot
- Potato wart
- Sudden Oak Death

*** Validation of model output currently being conducted**

Summary

- NAPPFAST can provide information (maps and graphs) to aid in survey and detection for CAPS
- Output information is customizable for end user
- A relatively new system – operational but developing
- Feedback needed for system improvements, development and maximum utilization

Interested in Learning More?

Hands on Demonstration session of **NAPPFAST**

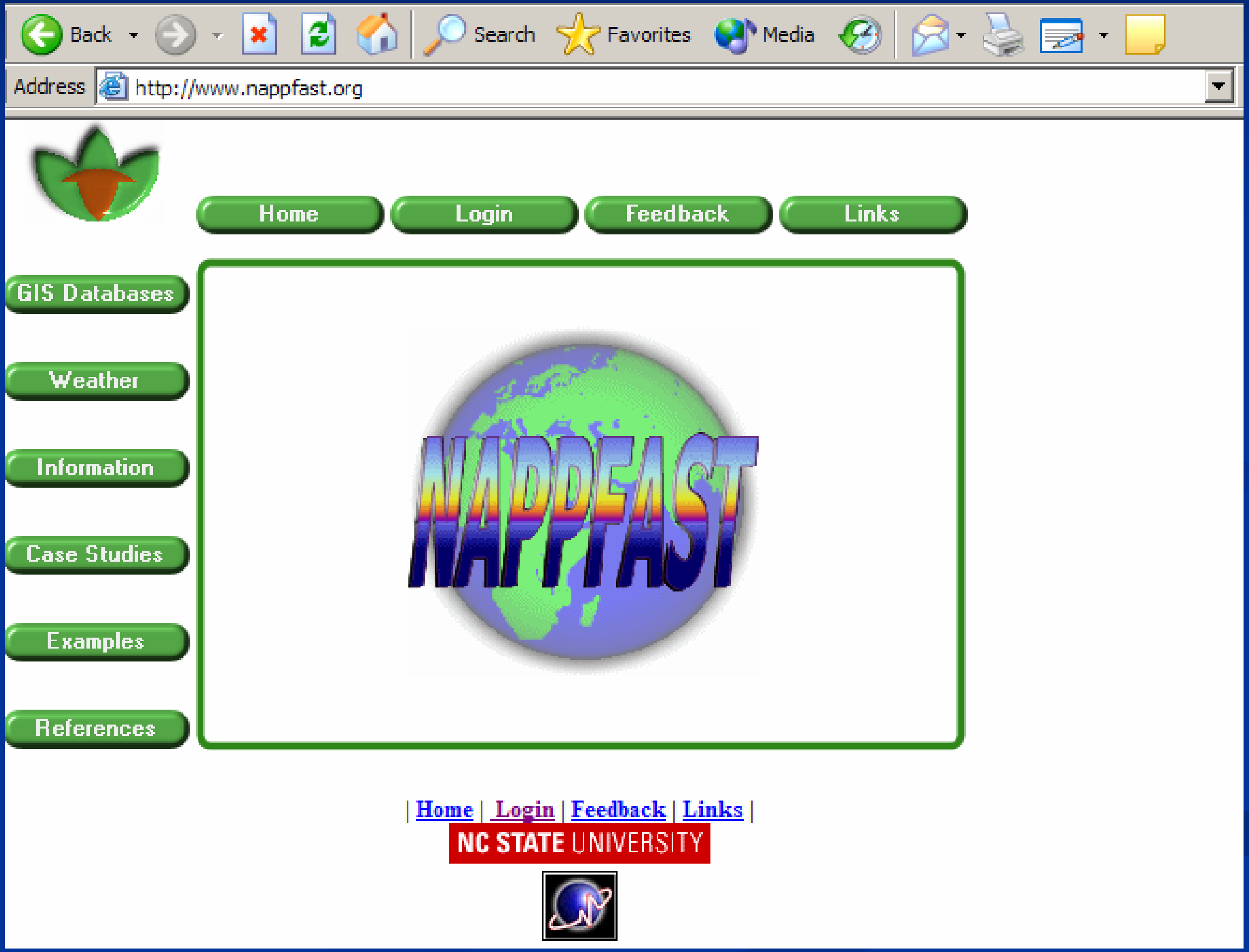
Wednesday, December 3:

4:30-6:30 pm

Central Park Rooms 1, 2 and 3

www.nappfast.org

Site contains information on GIS databases, weather data collection, case studies of modeling, Examples of pests examined and references



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